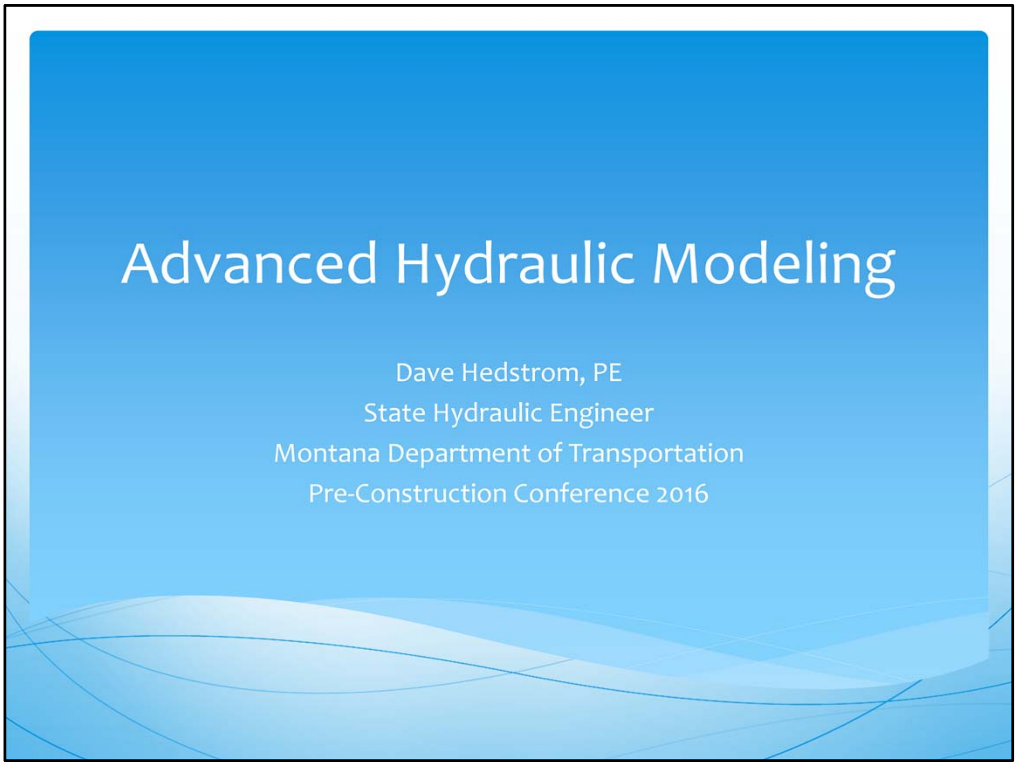
What's New in Hydraulics

2016 Preconstruction Conference



Introduction:

Speaker Notes:

Introduction: This is what 10,000 cfs looks like going over a US Highway

Speaker Notes: In 2013 10 inches of rain fell on this drainage resulting in an flood that was off the charts

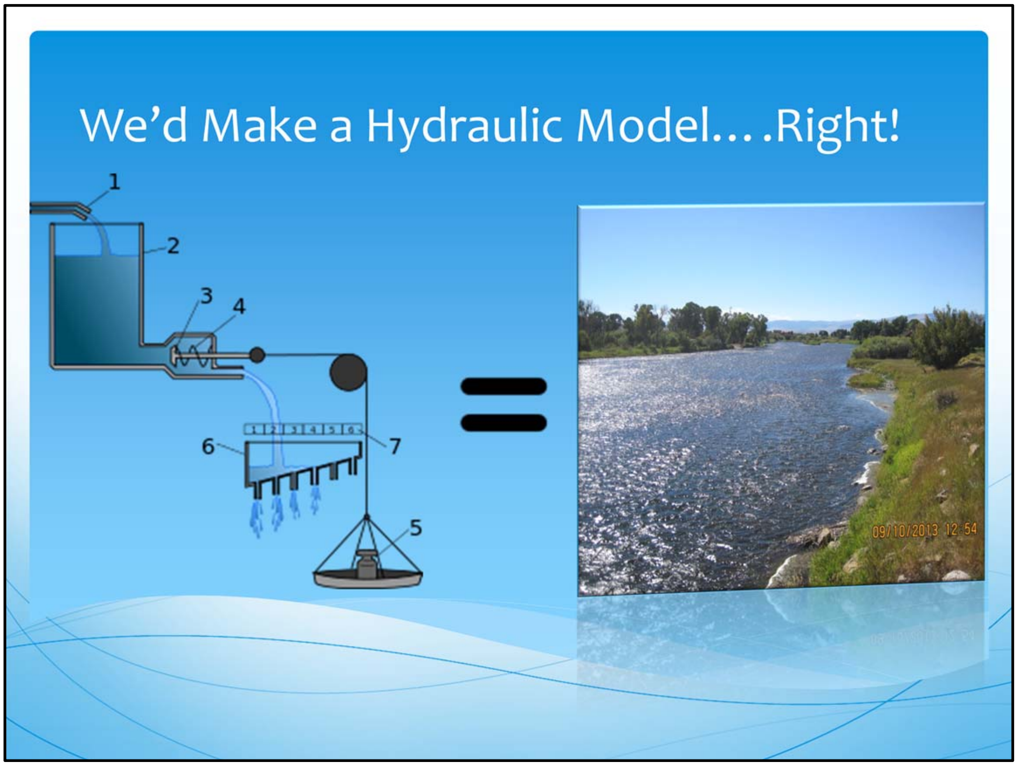
Almost 10 times the 100 year event

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:



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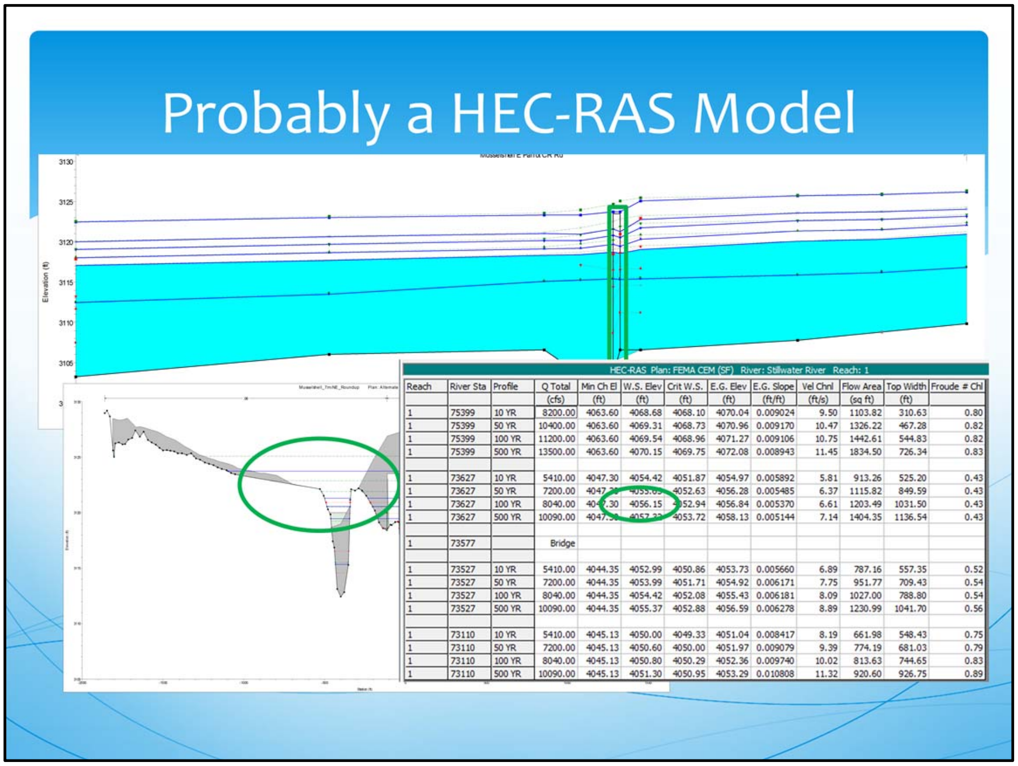


Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	75399	10 YR	8200.00	4063.60	4068.68	4068.10	4070.04	0.009024	9.50	1103.82	310.63	0.80
1	75399	50 YR	10400.00	4063.60	4069.31	4068.73	4070.96	0.009170	10.47	1326.22	467.28	0.82
1	75399	100 YR	11200.00	4063.60	4069.54	4068.96	4071.27	0.009106	10.75	1442.61	544.83	0.82
1	75399	500 YR	13500.00	4063.60	4070.15	4069.75	4072.08	0.008943	11.45	1834.50	726.34	0.83
1	73627	10 YR	5410.00	4047.30	4054.42	4051.87	4054.97	0.005892	5.81	913.26	525.20	0.43
1	73627	50 YR	7200.00	[illegible]	[illegible]	4052.63	4056.28	0.005485	6.37	1115.82	849.59	0.43
1	73627	100 YR	8040.00	[illegible]	4056.15	[illegible]	4056.84	0.005370	6.61	1203.49	1031.50	0.43
1	73627	500 YR	10090.00	[illegible]	[illegible]	4053.72	4058.13	0.005144	7.14	1404.35	1136.54	0.43
1	73577		Bridge									
1	73527	10 YR	5410.00	4044.35	4052.99	4050.86	4053.73	0.005660	6.89	787.16	557.35	0.52
1	73527	50 YR	7200.00	4044.35	4053.99	4051.71	4054.92	0.006171	7.75	951.77	709.43	0.54
1	73527	100 YR	8040.00	4044.35	4054.42	4052.08	4055.43	0.006181	8.09	1027.00	788.80	0.54
1	73527	500 YR	10090.00	4044.35	4055.37	4052.88	4056.59	0.006278	8.89	1230.99	1041.70	0.56
1	73110	10 YR	5410.00	4045.13	4050.00	4049.33	4051.04	0.008417	8.19	661.98	548.43	0.75
1	73110	50 YR	7200.00	4045.13	4050.60	4050.00	4051.97	0.009079	9.39	774.19	681.03	0.79
1	73110	100 YR	8040.00	4045.13	4050.80	4050.29	4052.36	0.009740	10.02	813.63	744.65	0.83
1	73110	500 YR	10090.00	4045.13	4051.30	4050.95	4053.29	0.010808	11.32	920.60	926.75	0.89

JR: Can we bring profile first circle the road, then the section and circle the overtopping, and then the profile table and circle the wsel before the bridge?

Introduction: 1-Dimensional Modeling utilizing the program HEC-RAS is currently predominantly used for modeling bridge openings at MDT.

Speaker Notes:

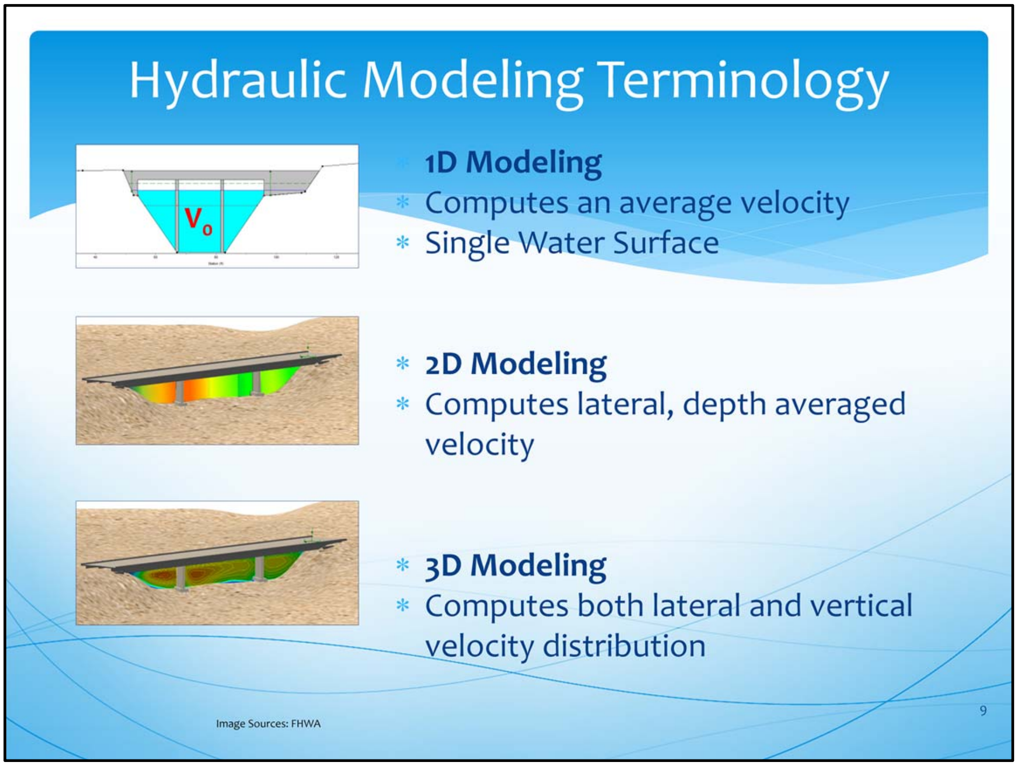
- 1-Dimensional Models track flow in one direction only (upstream to downstream) and changes in flow directions must be estimated by the design engineer. In addition these changes in flow directions must be predetermined before the model is built and ran.

- What you see here is a typical river reach profile created in HEC-RAS. *(click to bring up x-section)* And here is a typical cross-section from HEC-RAS.

Speaker Notes: This is another example of the 3D visualization tools available with 2D models. It shows an oblique view looking upstream along Shell Creek. This graphic depicts the 100-yr flood event.

{Open Animation}

You can also animate the results in 2D or 3D to create various visualizations that are very helpful with communicating results to others.



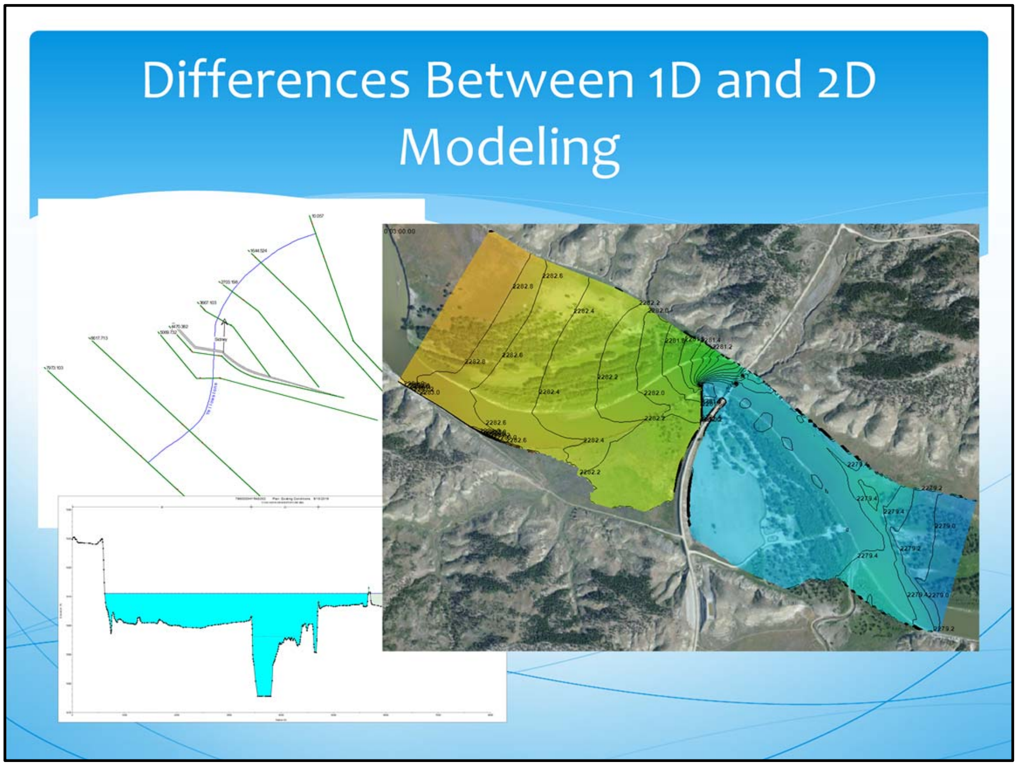
JR: Can we make the shrink after they grow?

Speaker Notes: Now that Scott has provided some history of hydraulic modeling, lets discuss some of the fundamental differences between 1D, 2D and 3D hydraulic modeling.

1D models, as depicted on the top graphic, only have one velocity magnitude, one direction and one water surface elevation per cross section.

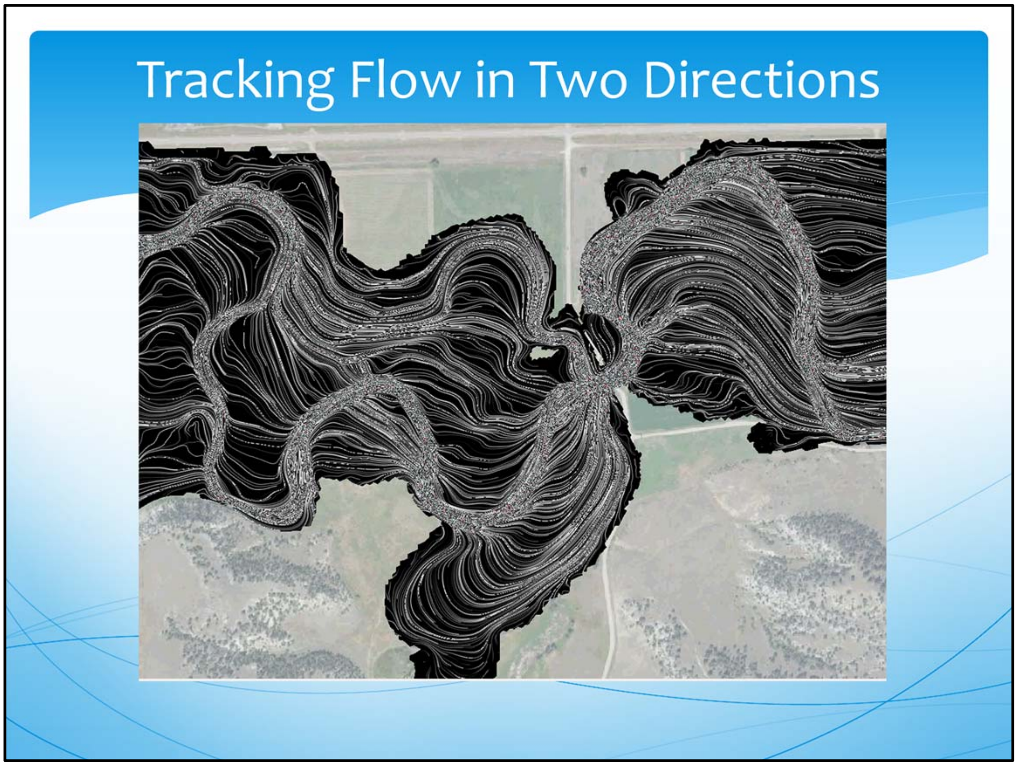
2D models, as depicted in the middle graphic, have velocities in two directions at specified intervals across the cross section. Note in the graphic, the velocities are the same from the river bed to the water surface, however differ across the cross section, with red depicting high velocities and green depicting slower velocities.. This is a big step forward from 1D models as we are now able to determine velocity magnitudes and directions at various infrastructure components rather than just one averaged velocity across the cross section.

3D models, as depicted in the bottom graphic, have velocities in three directions at specified intervals within the cross section. Note in the graphic, the velocities vary both vertically and laterally across the cross section, thus allowing for a very localized understanding of velocities and directions at the each of the infrastructure components.



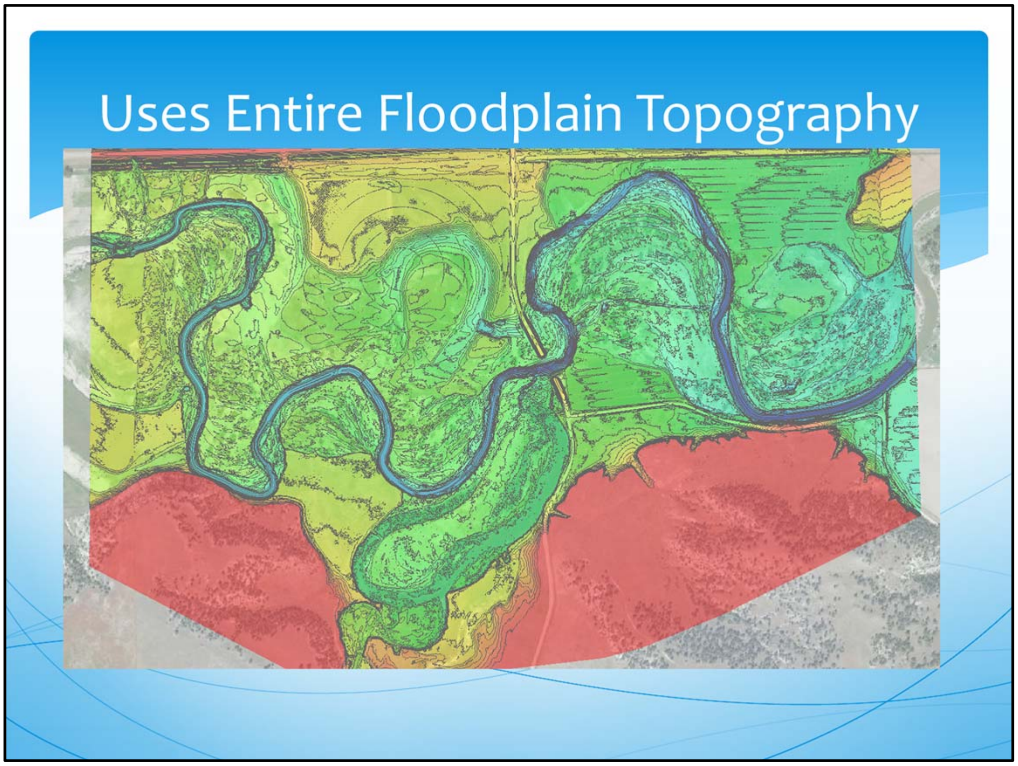
Introduction: What are some of the differences between traditional 1D modeling and 2D Modeling.

Speaker Notes:



Introduction: 25-yr event right at beginning of overtopping

Speaker Notes:



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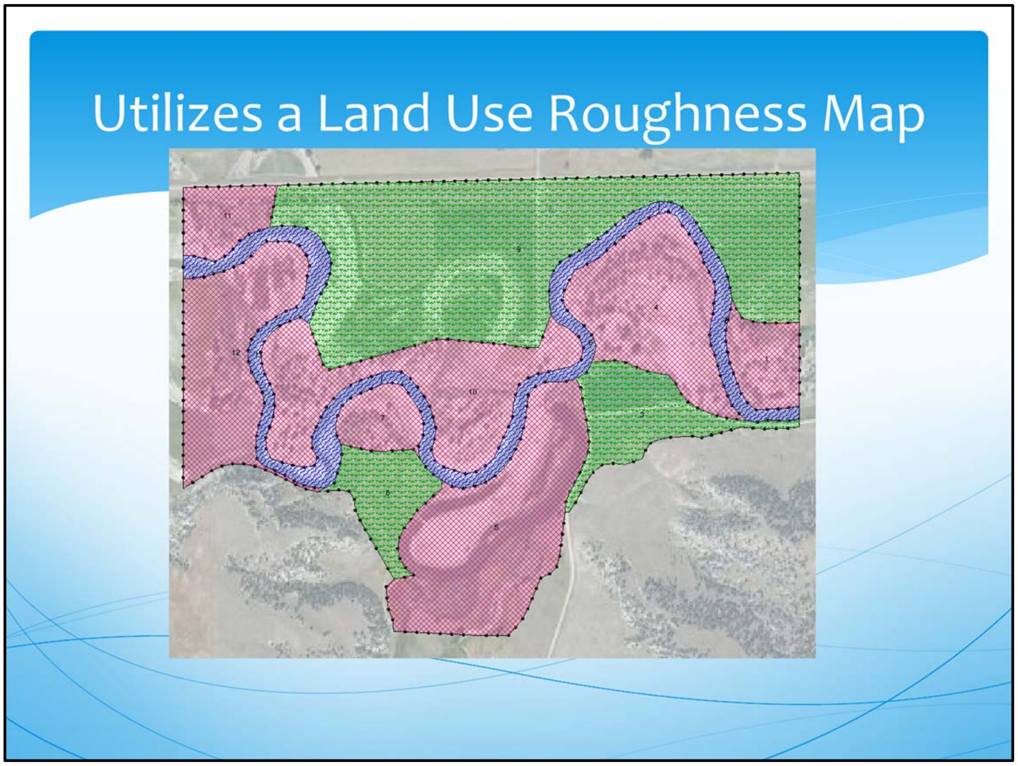

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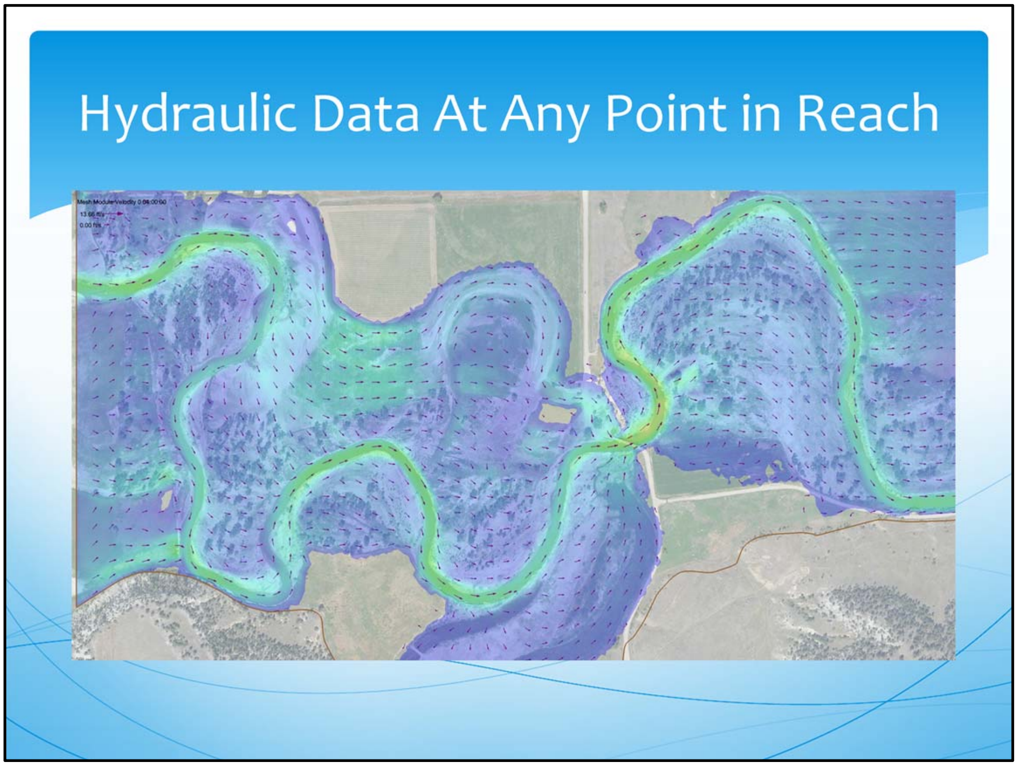

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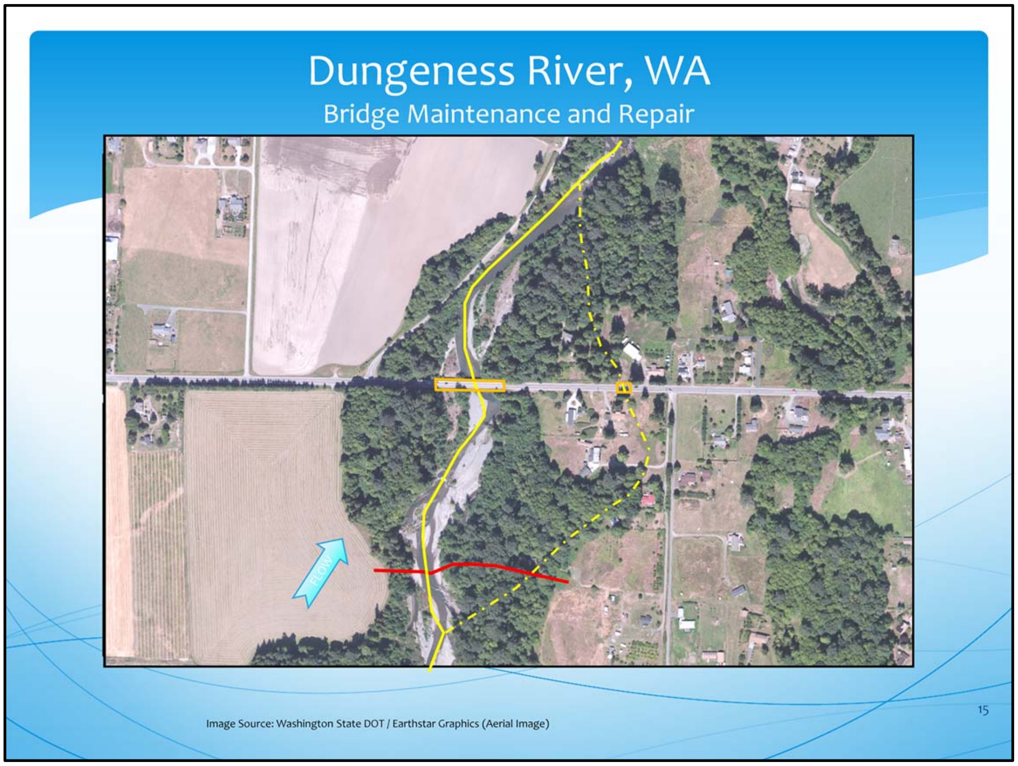


{ANIMATED SLIDE}

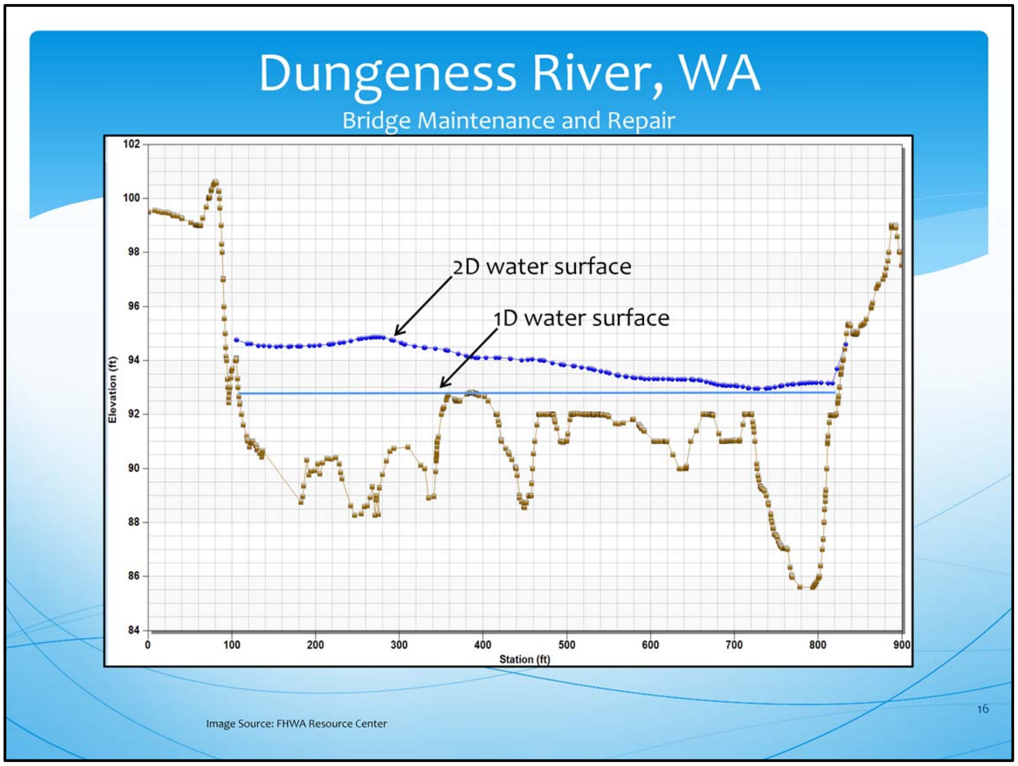
Speaker Notes: (click) This project on the Dungeness River in the state of WA involved a bridge (highlighted in orange, with a relief culvert) that was assessed as scour critical, which is a significant safety concern. Repairs and improvements were necessary, and a hydraulic modeling analysis was needed to evaluate the flow conditions at the bridge for mitigation design.

Initially, one-dimensional modeling was used, but ultimately two-dimensional hydraulic modeling was selected as the most appropriate tool for the project because of the complex hydraulics conditions, such as multiple flow paths (click) and adverse angle of attack on the bridge piers.

(click) For one-dimensional modeling, the channel geometry is represented by cross section data, and it assumes that flow is only in one direction (downstream), perpendicular to the specified cross section locations. As a modeler, it's often difficult to decide the orientation of the cross sections because flow is not always moving parallel to the main channel. In this case, there is a main flow path along the river and also a secondary flow path with a relief culvert to the right side of the bridge. As noted earlier, a 1D model assumes a constant water elevation across the width of the channel. (click)

Let’s take a look at an example cross section plot for the section highlighted in red, and also a water surface profile plot along the center of the channel, which is highlighted by the solid yellow line. (click)

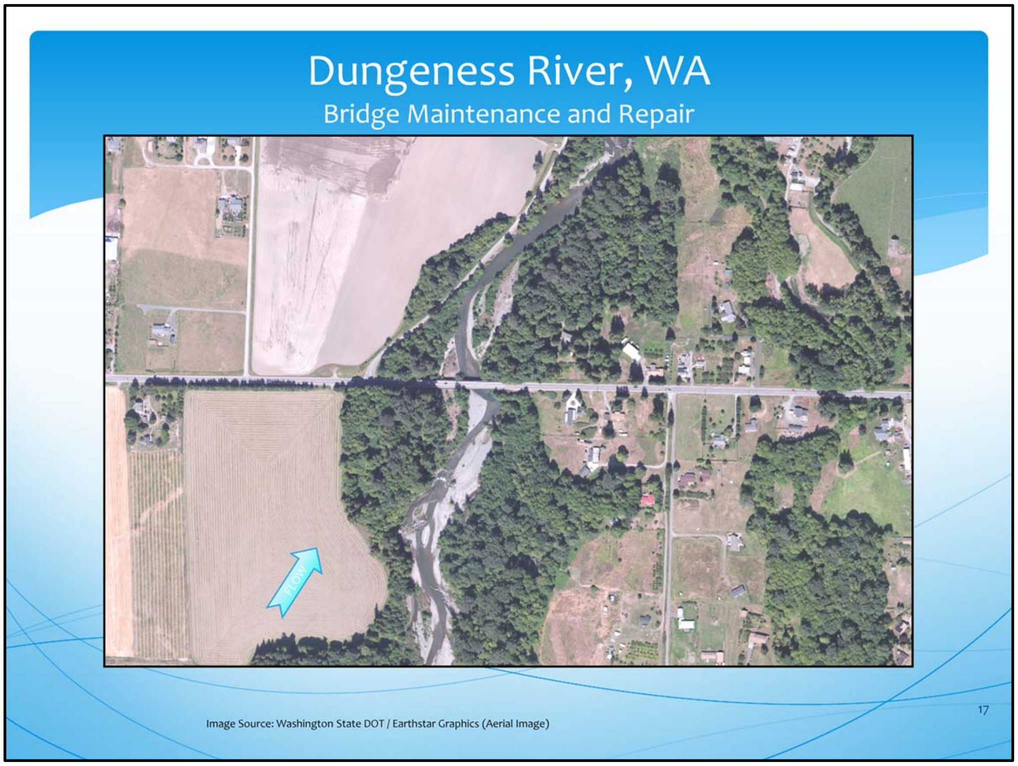
These plots are results from a one-dimensional model, and this is typically what hydraulic engineers use to communicate results to others. The top plot shows the water surface profiles along the center of the main channel (note bridge location), the bottom shows the channel cross section looking downstream. Note the constant water surface elevation in the lower plot.



Speaker Notes: If we compare the results from a one-dimensional and two-dimensional analysis, you can see that the 2D results show that the water surface is actually not constant, as shown by the 1D model results, and varies about 2 ft across the channel.

This can significantly affect flow distributions and hydraulics through a bridge, especially when the hydraulic conditions are complex and cannot be well represented with a 1D model.

Now, I don't want you to get the wrong impression hear about the elevation difference between 1D and 2D modeling. This example shows the 2D WSEL as being higher than the 1D WSEL, but that is not always the case. The key point is that the water surface is rarely a constant elevation, which is one of the primary assumptions in a 1D model.



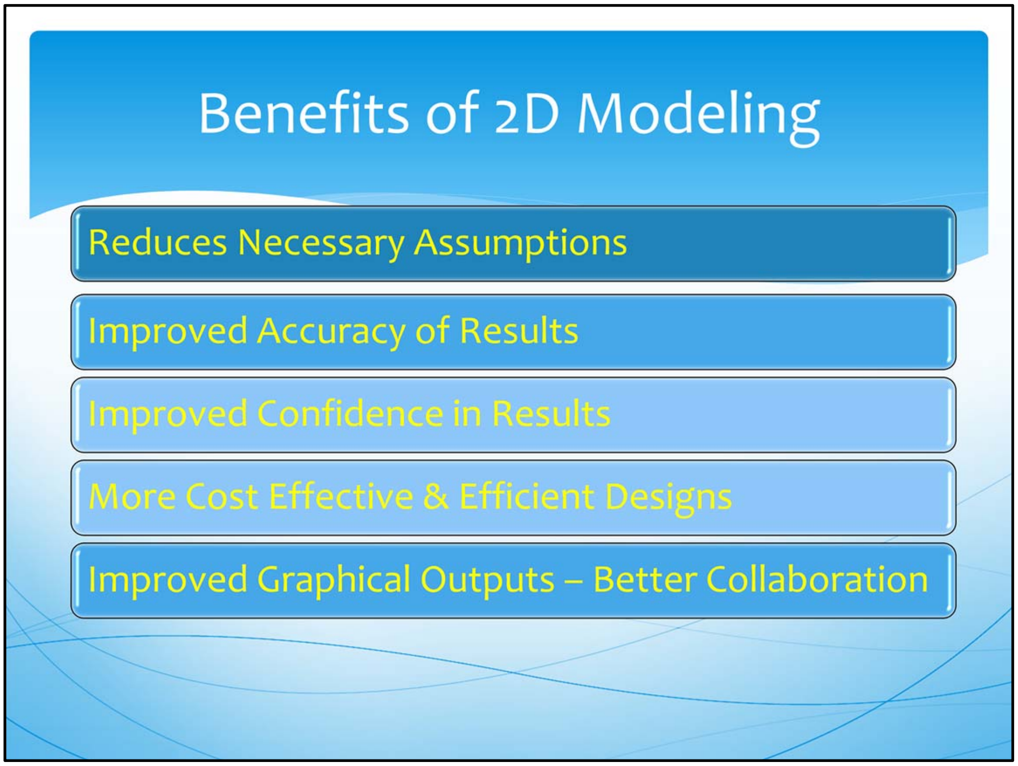
{ANIMATED SLIDE}

Speaker Notes:: (click) In a two-dimensional hydraulic model, the geometry is represented by a network of elements rather than cross sections, and it provides a better and more accurate representation of the topography.

This might look overwhelming at first, but let me assure you that this is actually much easier to develop a 2D model network than laying out cross section for a 1D model. Once you specify the limits of your project area, provide terrain mapping and a few parameters, this model network is generated automatically. A 2D model will compute water depth, velocity, and flow direction at each one of the elements to compute a better representation of the flow.

(click) This graphic shows an example two-dimensional model network with color elevation contours. **(click) (click)** {Wait for animation) With the three dimensional tools that are available with 2D modeling, we can rotate the model to review the topography and also view the results from different perspectives. You can view contours **(click)**, or an aerial image **(click),** as well as results showing the flood limits, flow velocities **(click),** and flow direction. **(click) (click)** You can also zoom in to evaluate detailed flow conditions through a bridge. You can see the three pier locations, shown as 'holes' in the results (**point**). The color contours represent the channel velocities and the arrows show the flow direction. On the upper left side of the screen you can see that the flow arrows approaching the pier are not parallel with the pier. This can lead to excessive erosion, or scour around the pier. Having an accurate representation of the flow direction is a significant benefit of two-dimensional modeling.

In 1D modeling, it is just one of the many assumptions that are made. The bottom line is that we often don't know what we don't know.



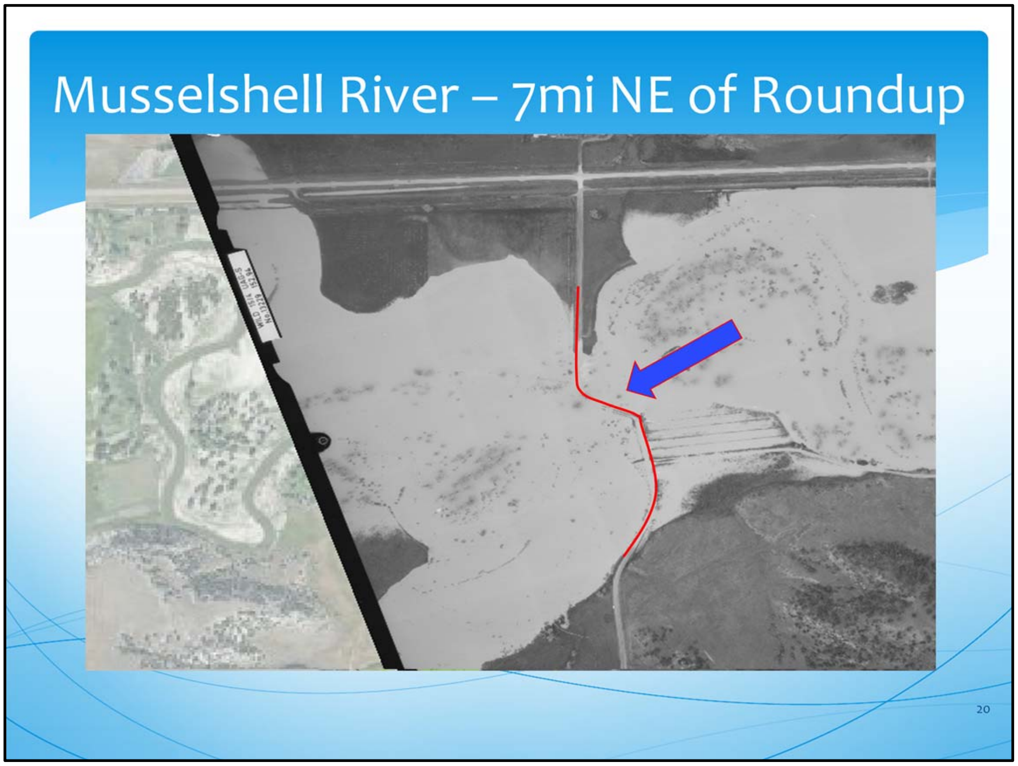
Introduction:

Speaker Notes:

How Has MDT Utilized 2D Modeling?

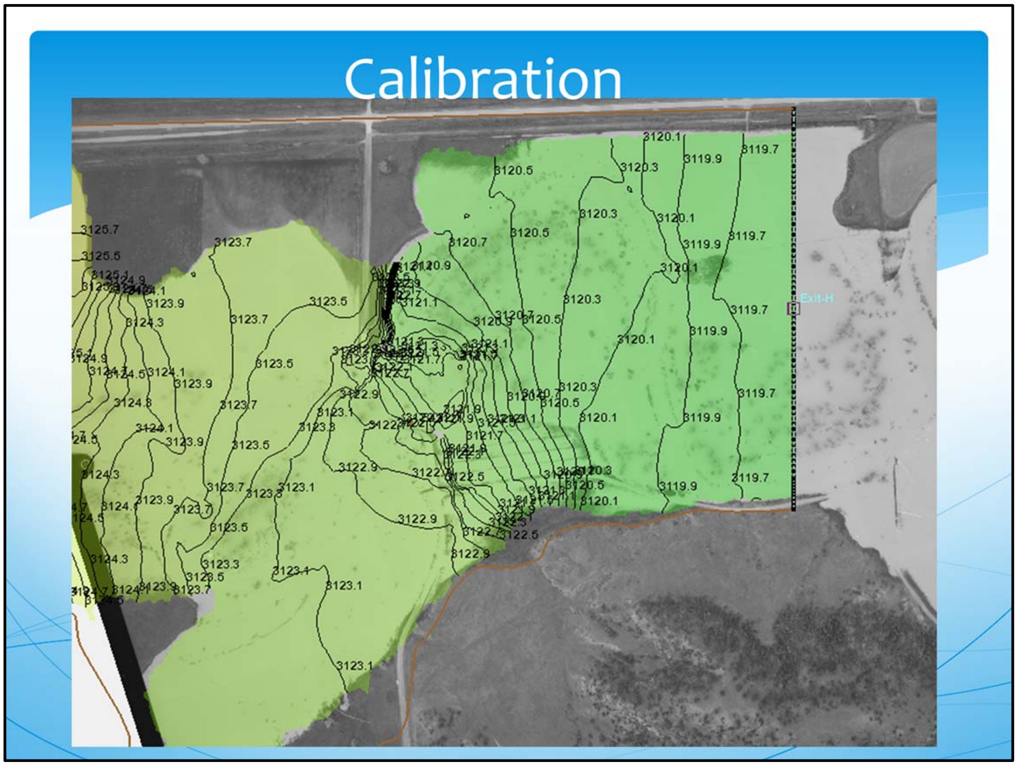
Three Project Examples:

- Musselshell River – 7mi NE of Roundup
- US-312 Crossing of the Yellowstone River
- Missouri River – Fred Robinson Bridge

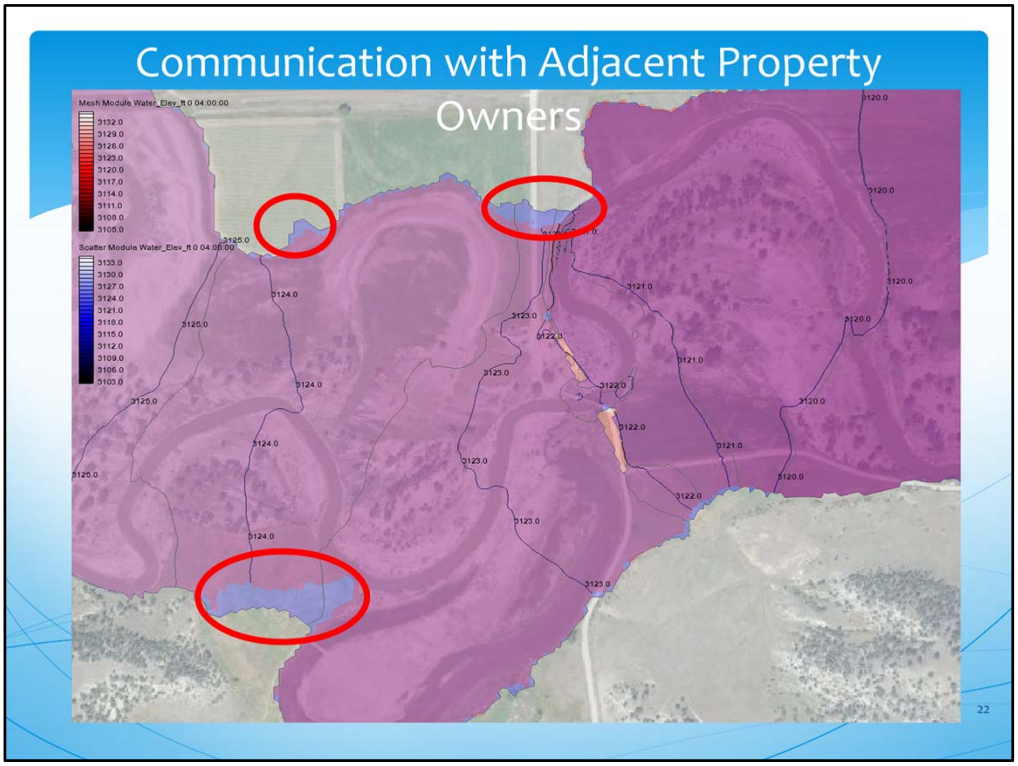


Speaker Notes:

- For this project we were reconstructing a county owned bridge and roadway over the Musselshell River in Central MT. The roadway had a 20% chance of overtopping every year. *(click to show bridge location).*
- One of our Key stakeholders on the project was the floodplain administrators, without whose acceptance the project would not have been a success.
- These individuals see real world events like our 2011 back to back 100-yr flood events, which you can see the flood extents in the aerial photo.
- Being able to easily overlay the water surface limits predicted by the 2D Hydraulic Model on to the flood aerial photo is a great benefit in convincing the floodplain regulators of how well the hydraulic model is calibrated to actual historical flood events.
- While the 2D model may not be something the regulators are familiar with a figure like this gives them confidence in what the model is producing for answers.



Another useful visual aide is the ability to super impose Historical aerial flood photos on to the calculated water surface plan view to ensure you have a model that replicates real-life.

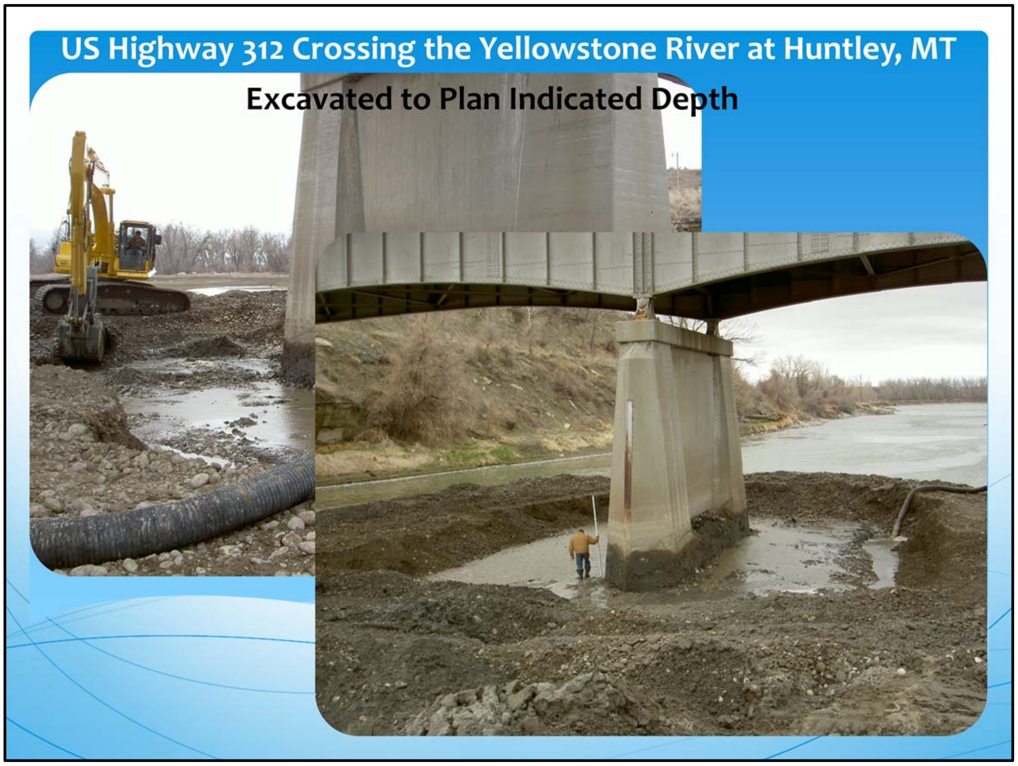


Speaker Notes:

- Another very important group of stakeholders on this bridge replacement project was the adjacent landowners, without whose approval the project could not have been success.
- Using the visualization tools in SMS/SRH-2D we were able to overlay proposed and existing water surface extents to show the few very minor areas of increased inundation *(click to show 3 areas of increased water surface).*
    - Here you can see the three small areas where flood extents will increase on the adjacent landowner properties.
- This figure allowed us to quickly get approval from the landowners and construct a new roadway and bridge that only had a 4% chance of overtopping every year.
- The 2D hydraulics model allowed us to quickly earn the support we needed to deliver the project 3 years ahead of time at the request of the local community.

Introduction: Installation considerations were developed after numerous internal and external meetings to allow the greatest amount of latitude to the contractor and still provide a satisfactory end product.

Speaker Notes:



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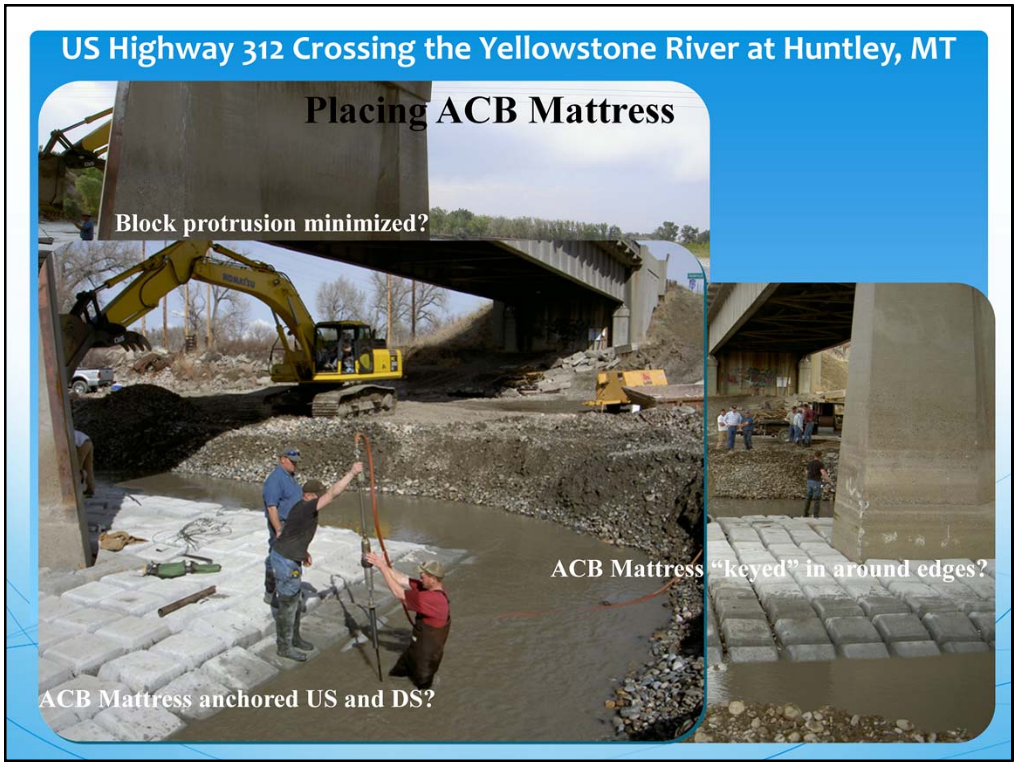
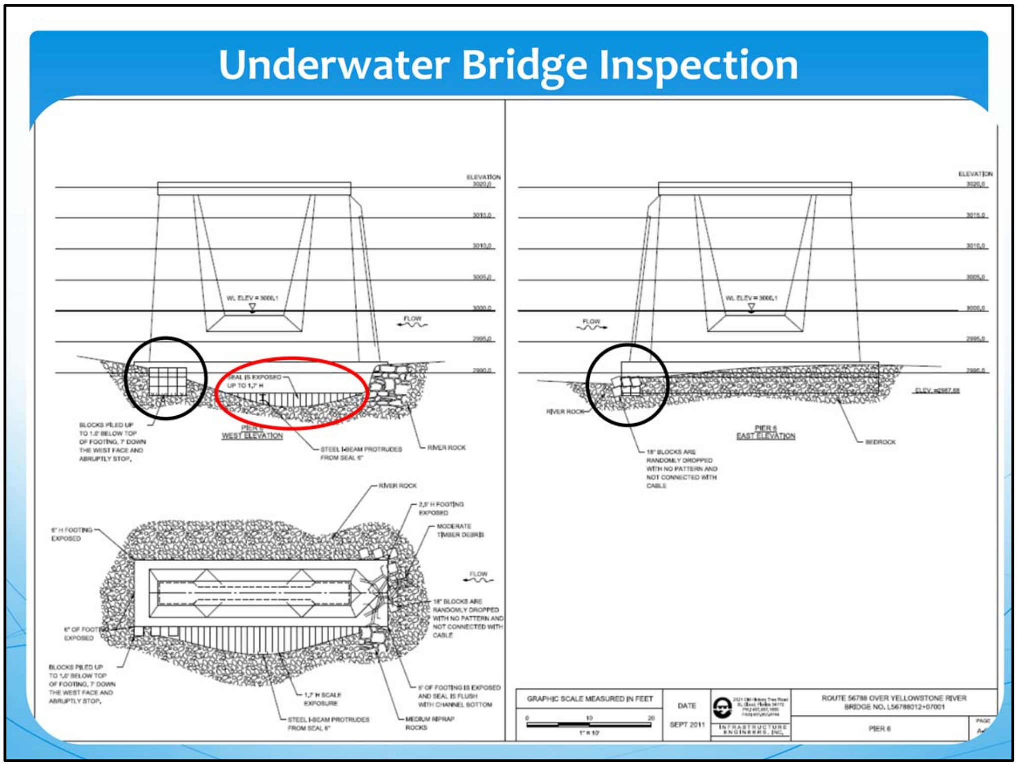


Introduction:

Speaker Notes:

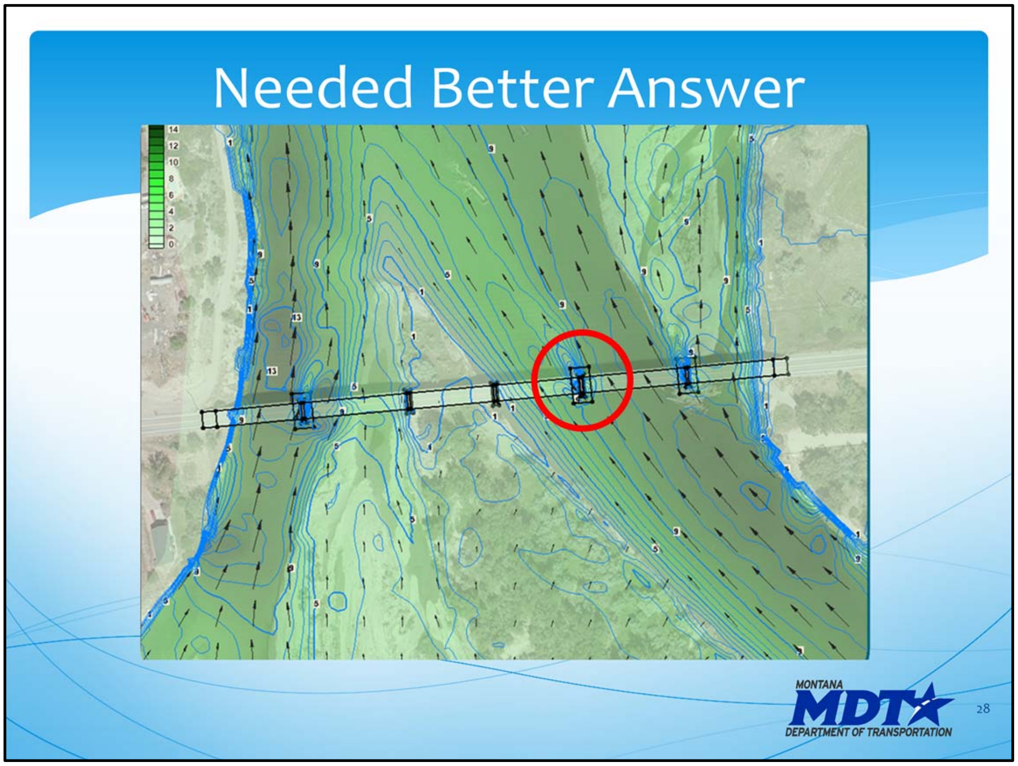
Introduction: Then the 2011 floods happened and our scour counter measures were tested.

Speaker Notes:



Introduction: The underwater inspection showed that a XX-yr flood event scoured away the ACBs and enough material around the pier to expose the seal below the footing up 1.7-ft.

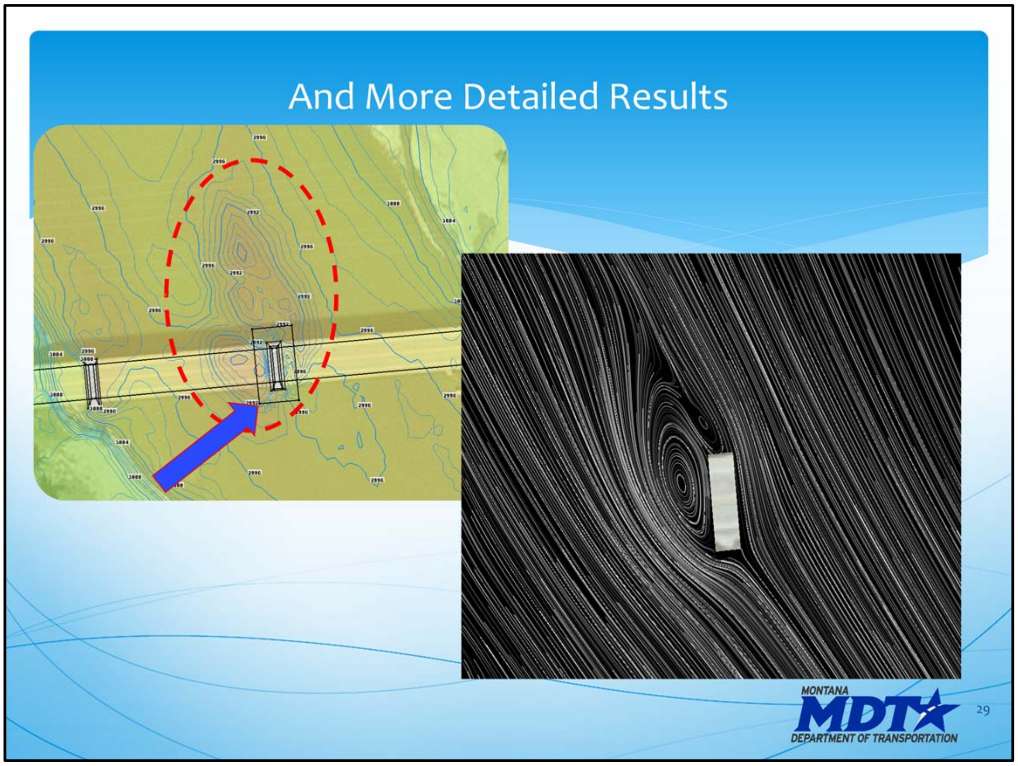
Speaker Notes:



Introduciton: So, We new that we needed better answers so that we did not replicate our mistakes.

Speaker Notes:

- We had a major failure of designed scour countermeasures for a bridge pier *(click).*
- The answers we developed from our 1D model led to an inadequate scour protection design.
- We needed better answers for the factors that cause scour:
  - Flow angles on the wall piers of a highway bridge
  - Velocities at the piers



Opening: We knew that we needed to develop a 2D Hydraulic Model to better analyze the scour at the bridge pier and avoid making the same mistake.

Speaker Notes:
- The square you see here *(click for arrow)* shows the limits of the original scour protection based on our 1D model.
- *(Click to remove arrow)*
- From bathymetric survey we obtained we could see the scour hole extended far beyond anticipated *(click to show circle)*.
- A 2D Hydraulic Model created in SMS/SRH-2D showed us the extents of the scour vortex at the pier. *(click-to bring up video)*
- **Play the video.** This is a flow trace video of the scour vortex at the pier.

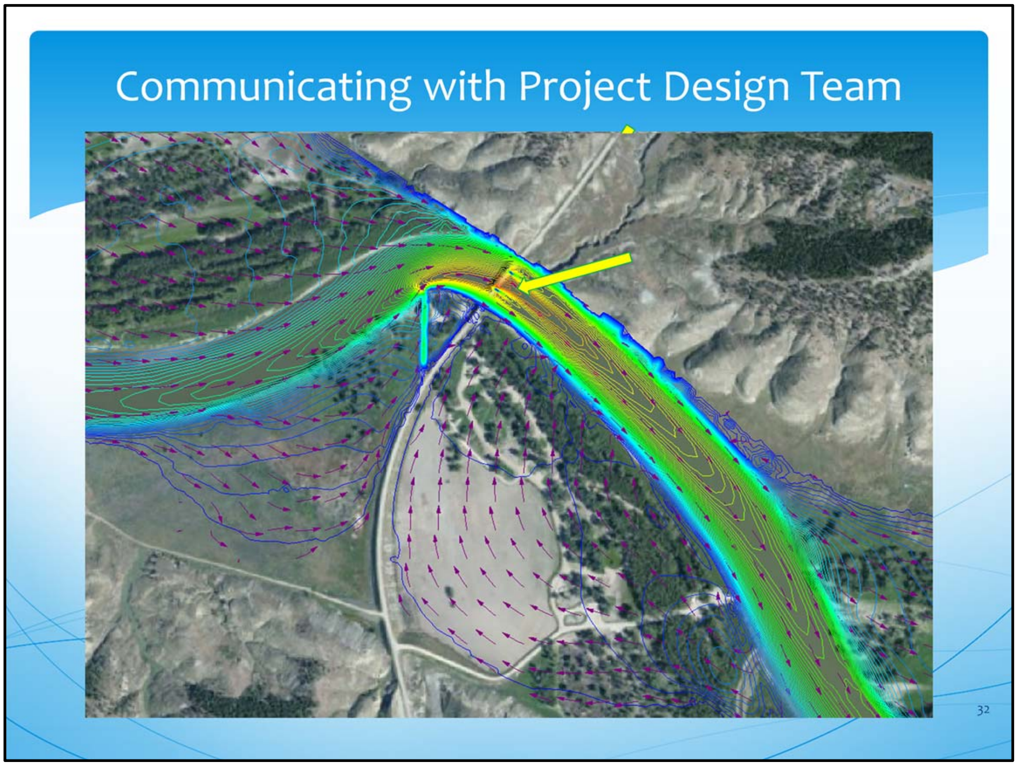
Missouri River
Fred Robinson Bridge

Introduction:

Speaker Notes:

Introduction:

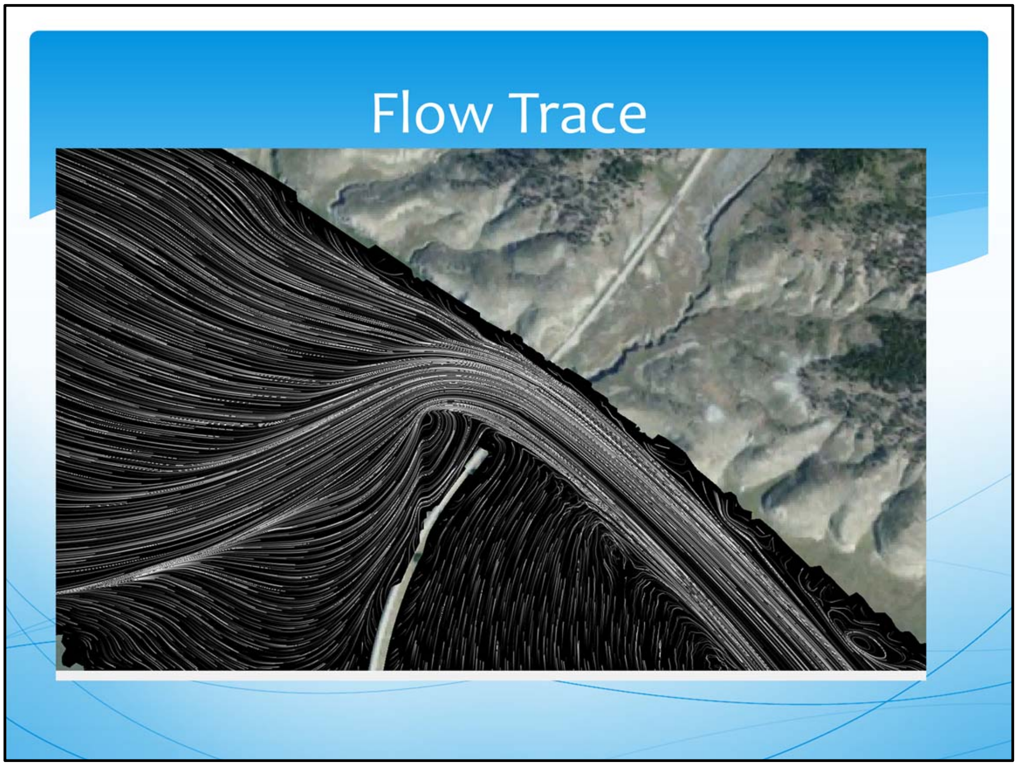
Speaker Notes:
- We need to design bank protection to prevent the bridge pier from failing.



Introduction: Here is an aerial view of the site, with the north bank having the erosion issue *(click to show arrow, click to remove).*

Speaker Notes:

- Here is the topography of the floodplain upstream and downstream of the bridge. *(click to show topo, highest elevations in red).* The 680-ft long bridge over the Missouri River upstream of Fort Peck Reservoir additionally had a dike constructed upstream when the bridge was built. *(click to show arrow, click to remove).* Looking at the topography one would assume the river regularly attacks the north bank.
- Utilizing a 2D model we were able to see that an upstream dike pulled the main river flows away from the sandstone cliff and toward the center of the channel, and this simple visual shown here *(click to show velocity contour map)* easily illustrates that to the design team stakeholders. *(click to show arrow, click to remove),* Here you can see the highest velocity location almost directly in the middle of the bridge instead of along the north bank
- Realizing that the velocities were less than anticipated at the bank allowed us to pursue non-standard bank protection measure and greatly reduce project costs.



Introduction:

Speaker Notes:

Introduction:

Speaker Notes:

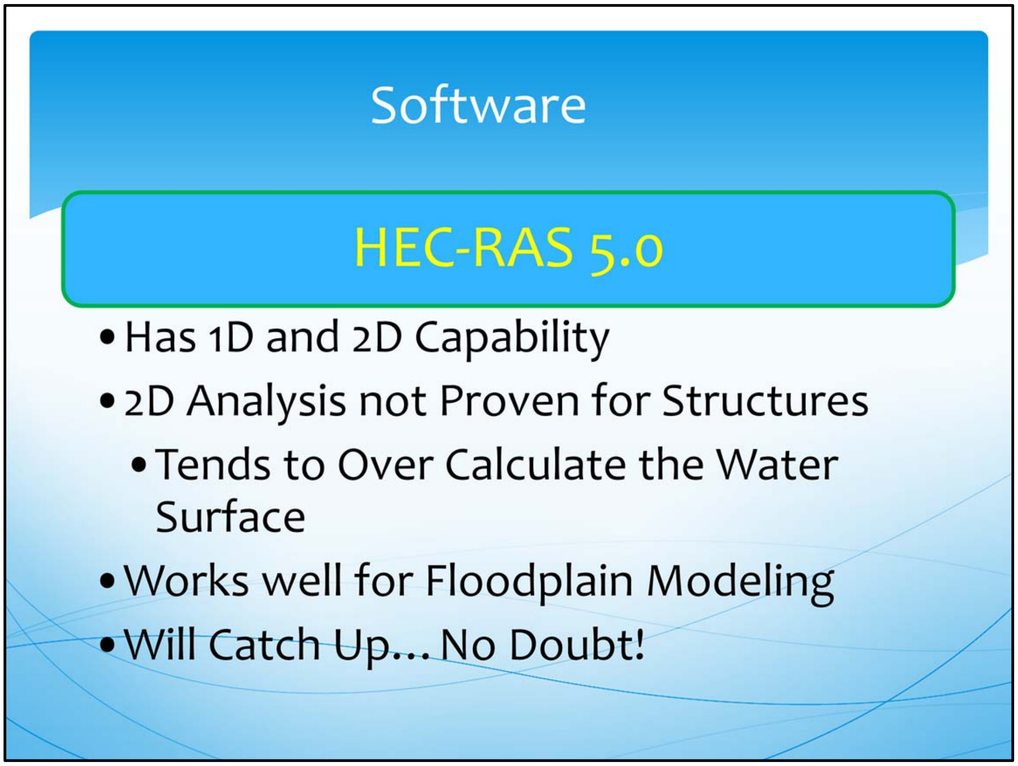
Software?

SMS / SRH-2D

HEC-RAS 5.0

Introduction:

Speaker Notes:



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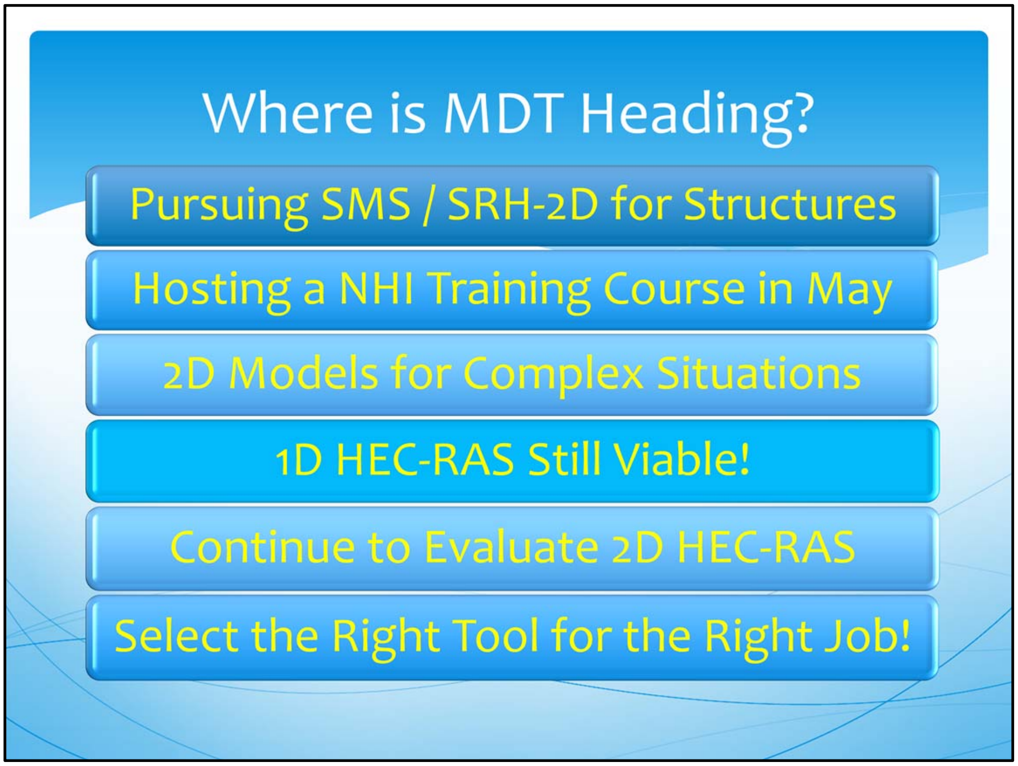

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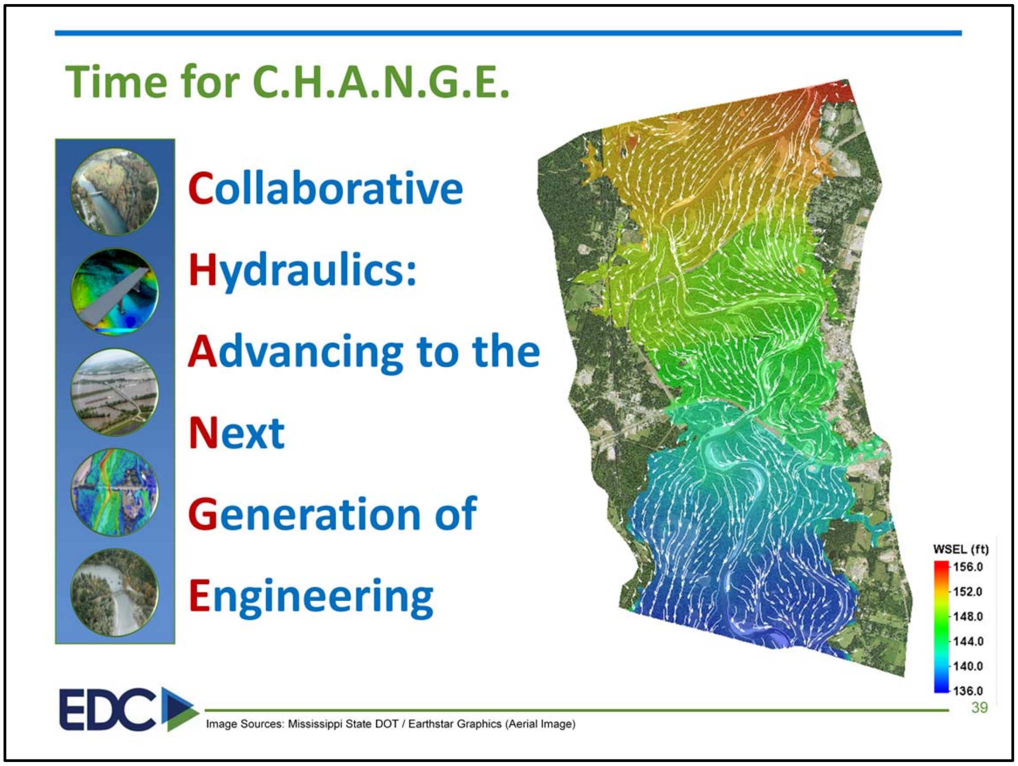
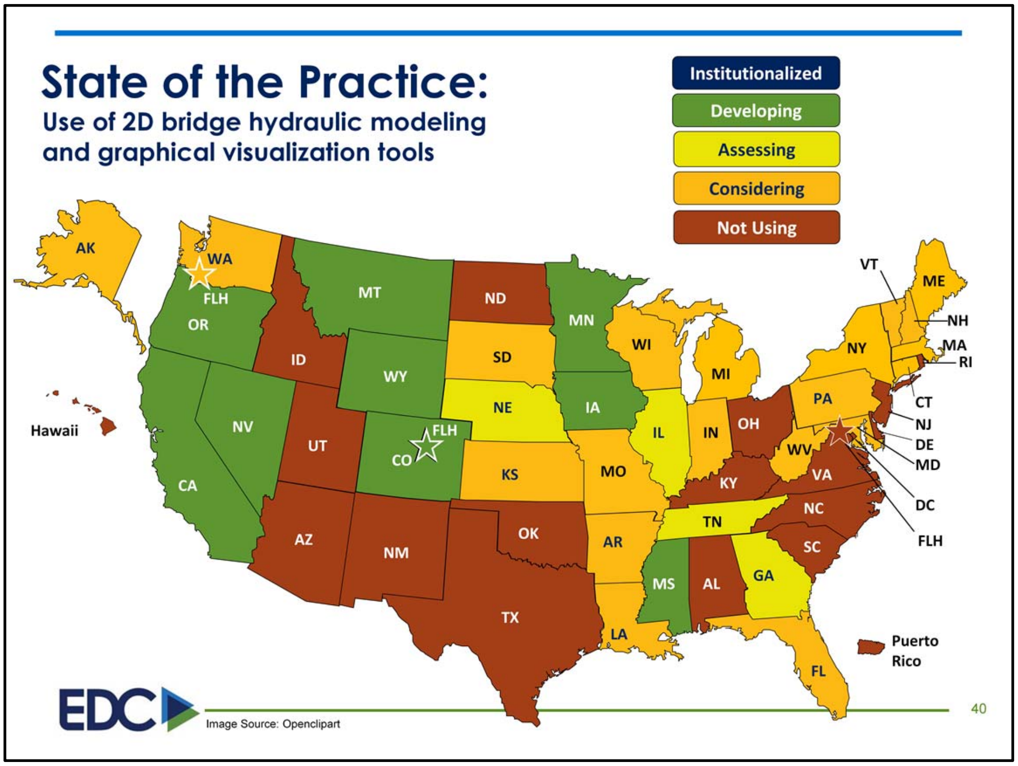


Speaker Notes – IT IS TIME FOR CHANGE!

In fact it is long overdue…. The most common method currently used for hydraulic analysis of bridges, and other roadway encroachments on rivers, is outdated and no longer appropriate for many applications.

The combination of hydraulic modeling methodology and graphical analysis tools that we are promoting with this innovation provide better tools for engineers and also offer a much better understanding of hydraulics to other disciplines and agencies, which leads to better communication and collaboration.

The technology and tools we are promoting have been developing for many years, and actually are currently used by several states to some degree, but recently there have been significant developments that make it much easier and more efficient to use. That's why it is now time for CHANGE.



Speaker Notes: Before we get into the strategies and resources, let me first show you a map of the states and give you an idea of the current state of the practice, with regard to the use of two-dimensional hydraulic modeling and graphical visualization tools. This gives a general idea of where states are at, but I need to point out that this image is a work in progress, and we are in the process of contacting states to see where they think they are at. I certainly don't mean to offend anyone here. If you think your state (or Federal Lands Office) is different that what we have shown here, please give me a call, I'd love to discuss it and update.

The main reason for this 'ranking' is that we need to have a performance measure for the EDC program. So we are currently trying to establish a baseline, and then after a year, and two-years of EDC, I expect that we will see a significant change in this graphic. We don't' show any states as institutionalized yet, because none are really fully aware of the latest tools that are available or have not completely moved into using 2D modeling. There are however, several states that have been using 2D modeling for a while; these are the ones shown in green. One of these states is MS, that has started using 2D modeling fairly recently, and have advanced rather quickly.

Before I present our strategies and resources, I'd like to have Don share about MSDOT transition the use of 2D modeling.

More info:

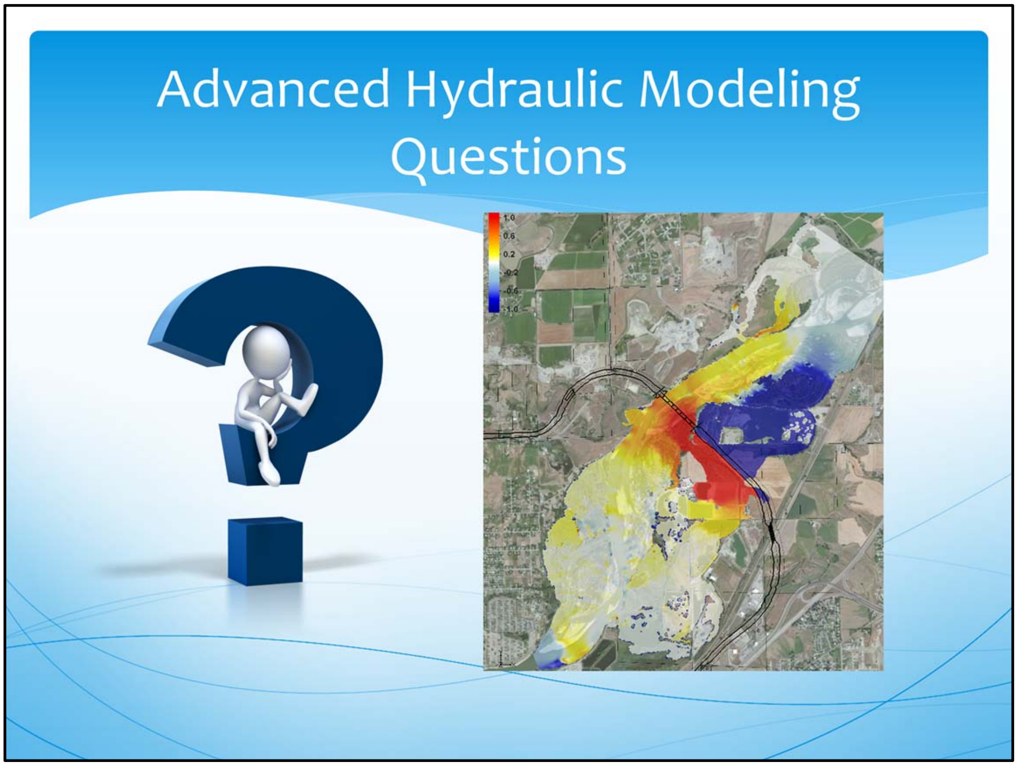
Not Using – Currently not using 2D bridge hydraulic modeling software. (i.e. if they have done some FESWMS modeling or other modeling in the past it doesn't count)

Considering – The state is interested in 2D modeling and has pursued it to some degree (training, webinars, workshops, etc.) – downloading SMS doesn't count

Assessing – The state is actively evaluating/testing current 2D bridge hydraulic modeling tools on their projects

Developing – The state is using 2D modeling on their projects and is moving towards institutionalizing it into their policies, procedures, and guidelines (need more training, help with guidance, need help expanding to more staff, need technical support, needs to develop a champion

Institutionalized – The state has adopted 2D bridge hydraulic modeling and graphical visualization tools for project delivery, when appropriate and has institutionalized 2D bridge hydraulic modeling in its policies, procedures and guidelines.



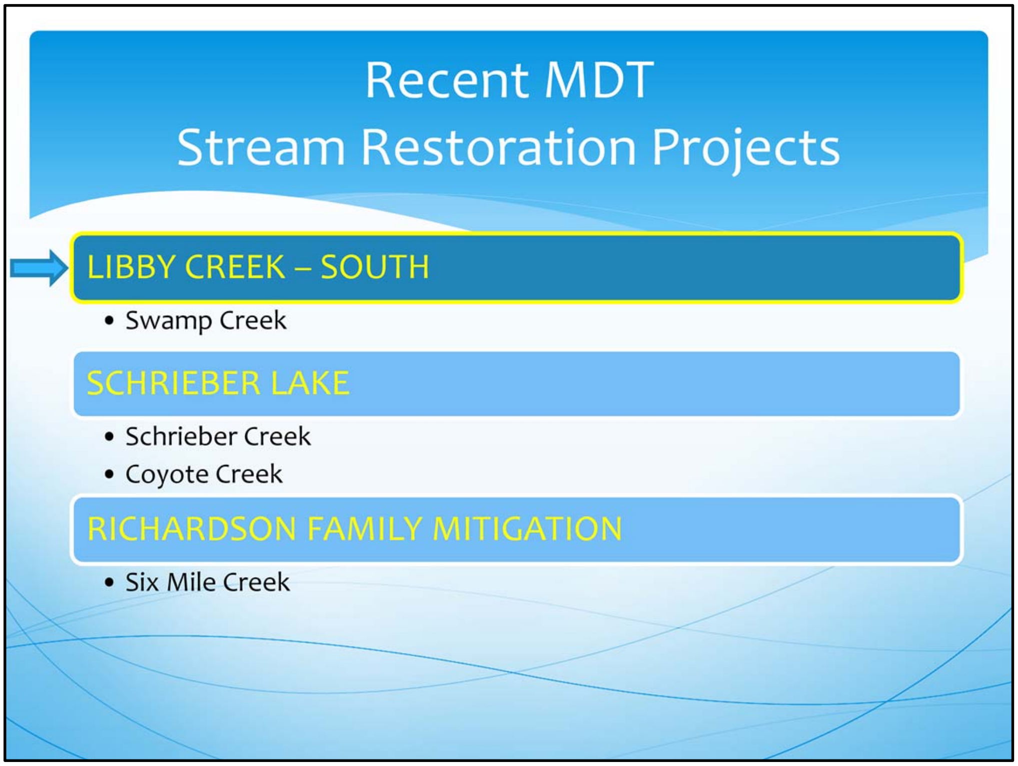
Introduction:

Speaker Notes:

Stream Restoration probably isn't what comes to mind when you hear the Montana Department of TRANSPORTATION.

However, due to impacts to rivers from roadway reconstruction projects, and as a means to gain stream mitigation credits. MDT has been involved in several stream restoration projects over the last several years.

I am going to walk you through three of these projects to show you what we have achieved and what we have learned.



Libby Creek South is a Roadway Reconstruction Project with a Stream Reconstruction of Swamp Creek.

Schrieber Lake and the Richardson Family Mitigation Projects are both stream /wetland mitigation projects.

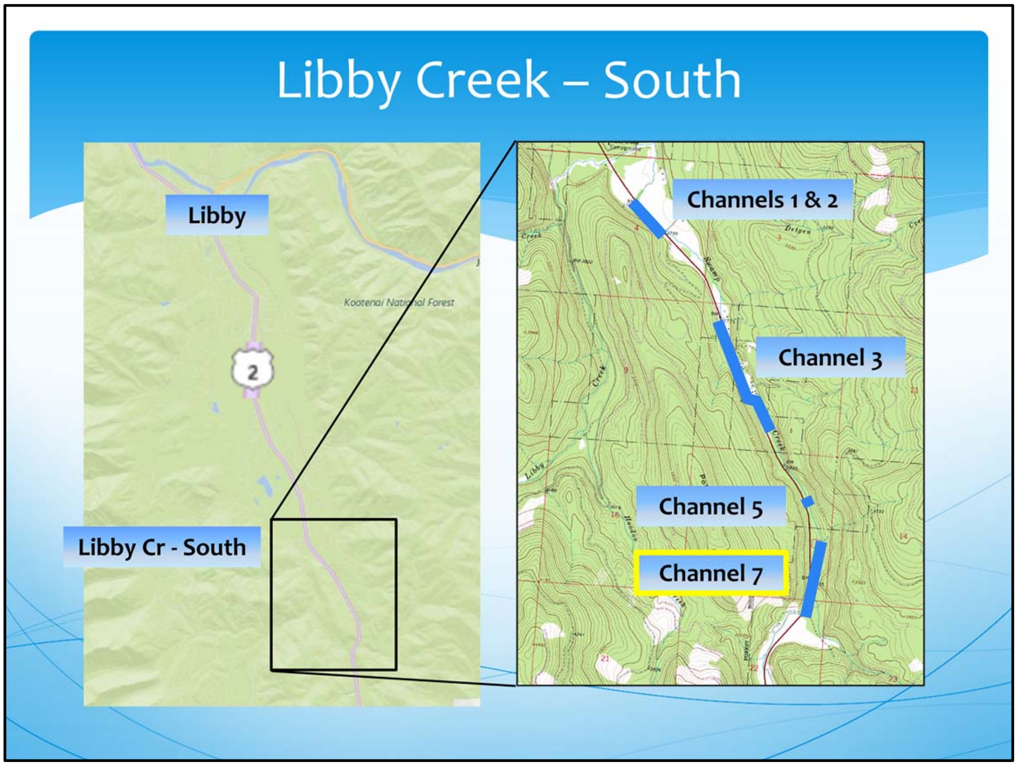
Libby Creek South was a $12 Million major reconstruction project.

This shows the Swamp Creek Channel Prior to Construction.

The stream had been moved by landowners into the MDT roadside ditch.

As you can see from the photo,
- The road has No shoulder
- Need the roadside ditch to widen the road.
- Moved the stream back out into its floodplain.
- Restored over 2 miles of stream in 5 segments.

The project was let in September of 2013 and



Shows the Project Location
NW Montana, Libby, US2 south of Libby
5 Segments of stream

Since the existing channel was right where the road needed to be widened, the first order of business was to move the channel.
Since the project was let in September, a lot of the channel construction occurred in the fall and winter.
I’m going to walk you through a series of photos of channel 7.

By June of 2013, the construction was complete.

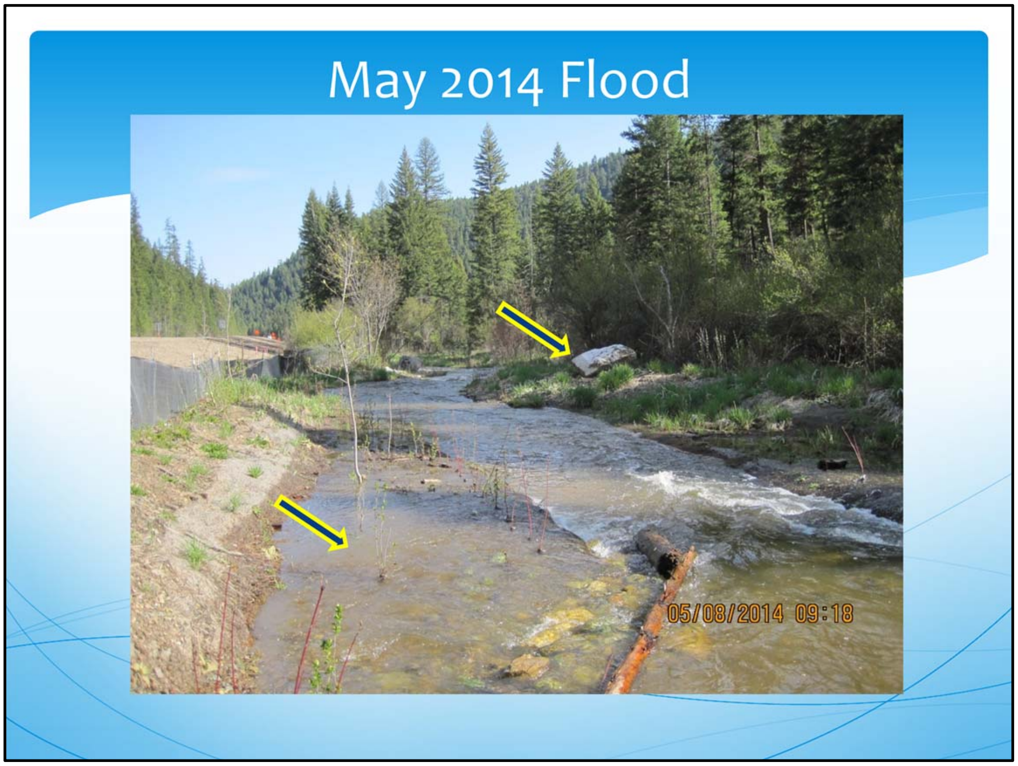
Note the two rocks in the picture *(click to bring up arrows)*, you will be able to see these rocks

Through the next series of photos, we will use the rocks to keep track of our locations.

See coir fabric on the banks and freshly planted alders.

Here is another view of the same section with people for scale

By October of the same year, the vegetation had really started to take off.



In May of the following year, a small flood event hit the stream.

Speaker Notes:
- Kind of Scary on a raw stream, however
- It was designed to get up and out of banks to relieve pressure on the stream and activate the floodplain—doing what it's supposed to.
- Mother Nature's seeding program.

Introduction: Here is that same section of channel two months after the flood

Speaker Notes:

Introduction: 3 months after the flood there are young Alders growing *(Click to show arrow).* Just to the left of the Alders you can see the rock pointed out in the first slide showing this reach.

Speaker Notes:

One of the benefits to stream restoration is better habitat for fish and wildlife.

Vegetation almost touching

Introduction: Aquatic insects are heavily present in the restored reaches of swamp creek

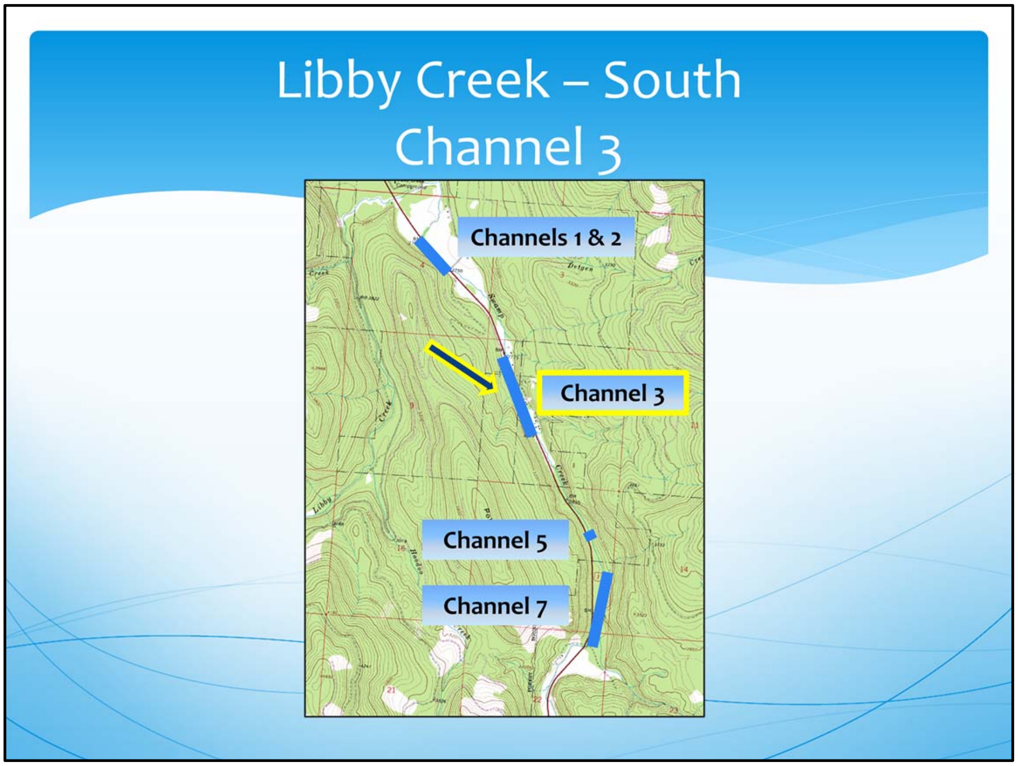
Speaker Notes:
- Here you can see several May Fly nymphs *(click to show arrow)*

Introduction: Here is a caddis nymph

Speaker Notes:

Introduction: And some stone fly nymphs

Speaker Notes:



Shows the Project Location
NW Montana, Libby, US2 south of Libby
5 Segments of stream

Introduction: Here is a section of Channel No.3 seeded with human means

Speaker Notes:

This channel has a little different story.

A flood hit this channel in the spring of 2013.

During design we had several bore holes along the project and the soils looked gravelly, and suitable for streambed.
However, it turned out that the soils were highly variable, and
when they constructed this section of channel, the soils in this section had very little gravel.

So, when a flood hit, the channel down cut.
Keep an eye out for these rocks in the next series of photos.

Introduction: Here is the same stretch in August 2013

Speaker Notes:
- You can see some down cutting has occurred in the channel
- Channel No.3 did not utilize a designed streambed material like Channel No.7
- It was anticipated that there would be enough gravels present in the insitu material to develop an established streambed

Introduction: Here is the same section of restoration a couple months later

Speaker Notes:
- You can see of the channel bottom has settled out and is now performing as desired

Introduction: Here the reach is experiencing the high water event in Spring of 2014

Speaker Notes:

Introduction: And the section of Channel No.3 in August of 2014.

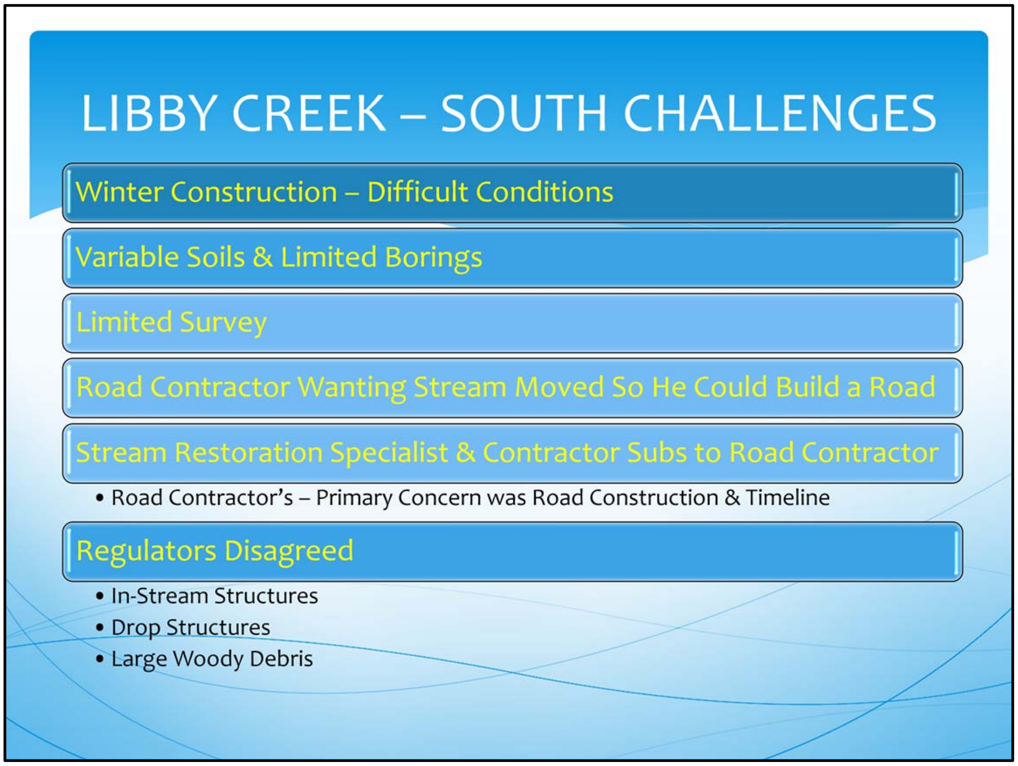
Speaker Notes:

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:



Introduction:

Speaker Notes:

Introduction: Here is Swamp Creek before restoration *(click to show pic)*, and here is after the restoration

Speaker Notes: We had some challenges, but after 3 years, it’s looking pretty good.

Libby Creek South is a Roadway Reconstruction Project with a Stream Reconstruction of Swamp Creek.

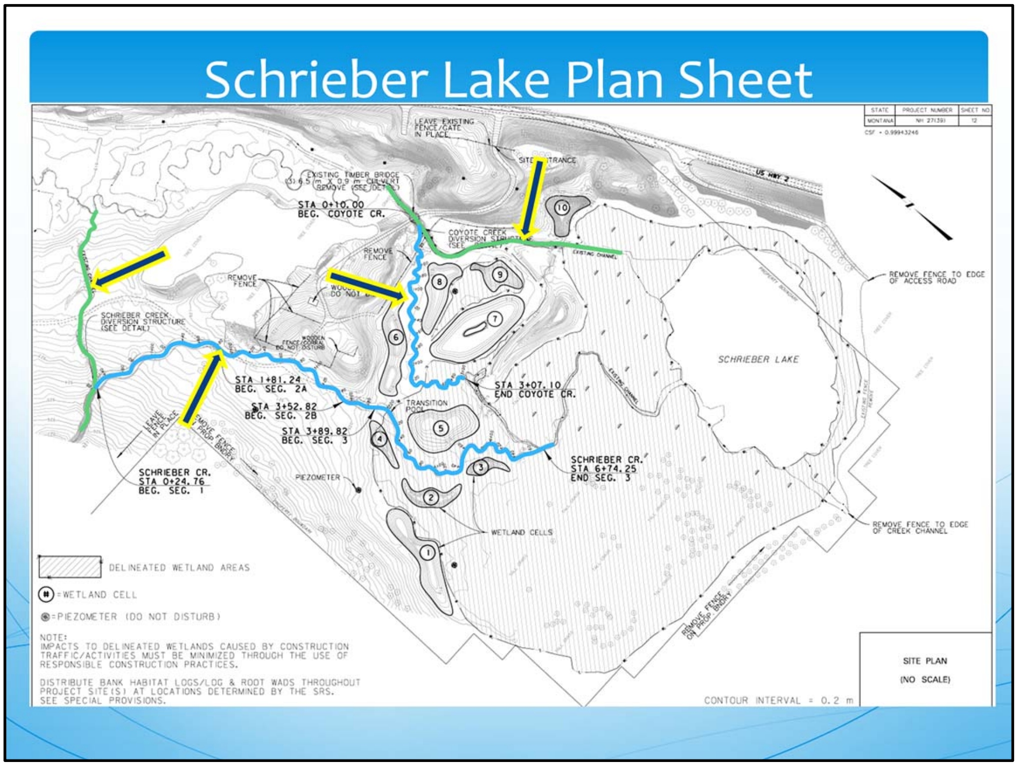
Schrieber Lake and the Richardson Family Mitigation Projects are both stream /wetland mitigation projects.

Introduction: Project South of the Libby Cr S Project

Speaker Notes:
- Stream Not Following Its Natural Path

- Gain stream and wetland mitigation credits.

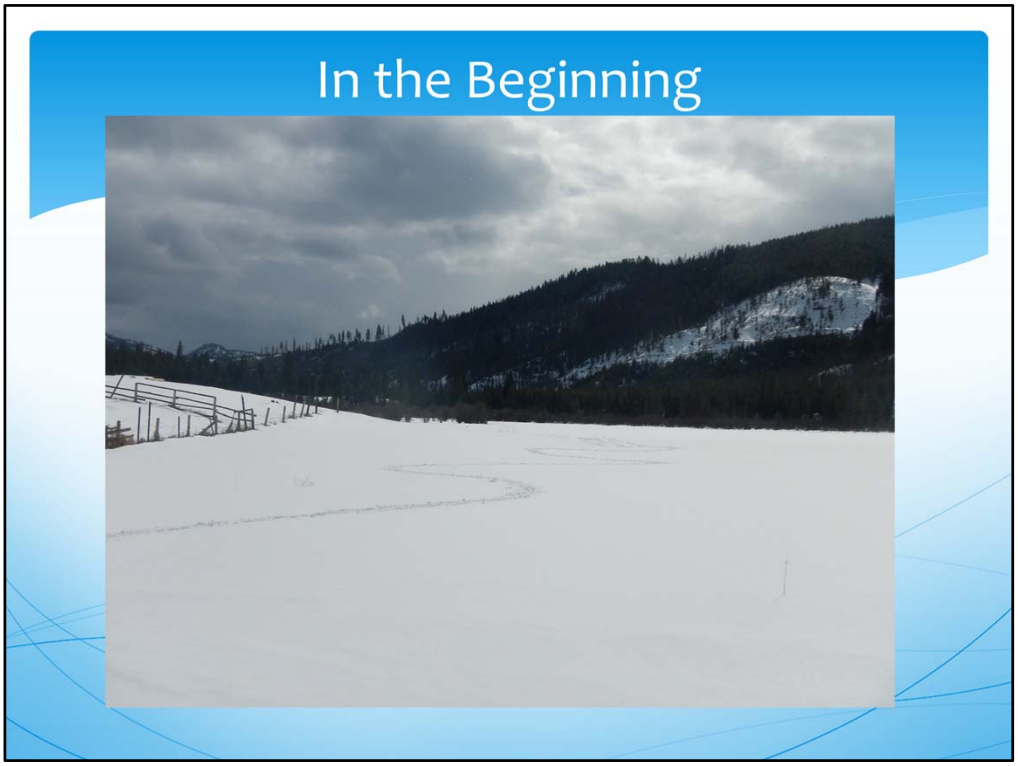
- Put stream back into its basin



Introduction: this is the plan view of the Schrieber Lake Project

Speaker Notes:

- Here you can see the Schrieber Creek Channel prior to restoration *(click to highlight)*, and the Coyote Creek Channel prior to restoration *(click to highlight)*
- This is the Restored plan reach for Schrieber Creek *(click to highlight)* and the restored plan reach for Coyote Creek *(click to highlight)*



Introduction:

Speaker Notes:

Introduction: Here is that same section without as much snow

Speaker Notes:

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:

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Speaker Notes:

May 2015

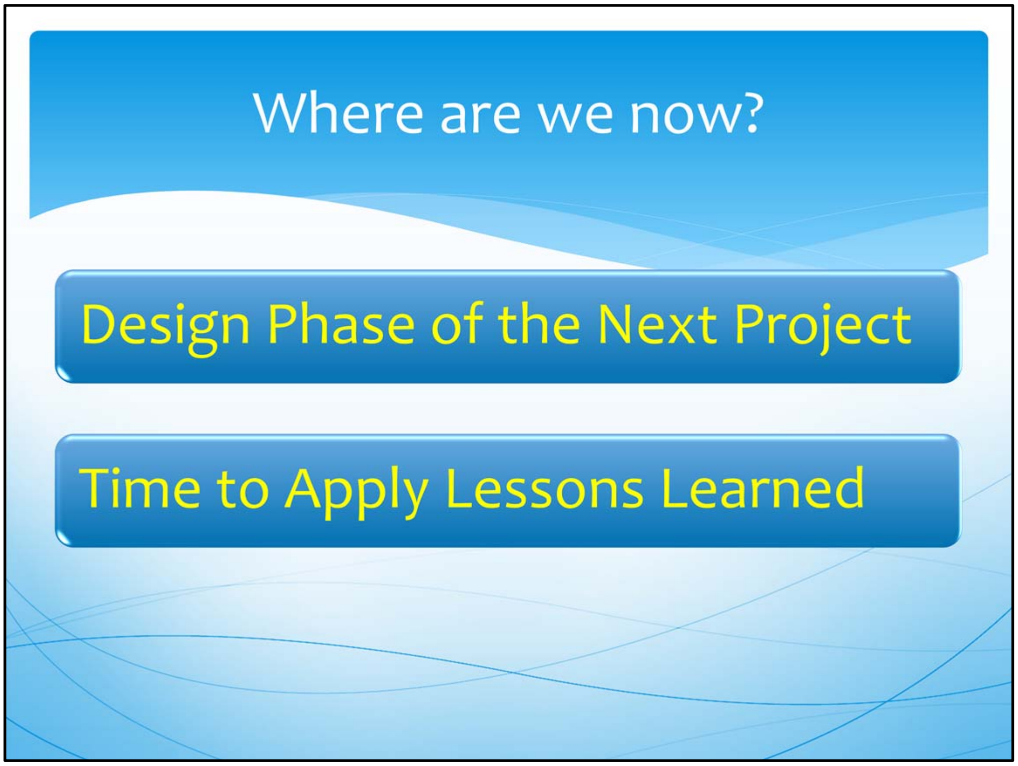
May 2015

Introduction:

Speaker Notes:

Introduction:

Speaker Notes:



Introduction:

Speaker Notes:

This takes us to the third project, which is another stream and wetland mitigation project.

Introduction: 13 Miles West of Missoula, Near Huson, Just North of I-90.

Speaker Notes:
- Stream and Wetland Mitigation Project
- Still Under Design

Introduction:

Speaker Notes:

Introduction: Here is an aerial view of the project site, with the existing channel located here *(click to show arrow, click to remove)*

Speaker Notes:

- Existing Channel Straightened by the Former Land Owner to farm more land
- Current Location/Former Meanders
- Reference Reach Section
- Upper 6’ Diameter Steel Culvert Location/Fish Barrier
- 90” Steel Culvert Under I-90
- There are three distinct segments of restoration
    - The Upper Section here *(click to show arrow, click to remove)* consisting of
    - The Middle Sections here *(click to show arrow, click to remove)* consisting of
    - And the Lower Section here *(click to show arrow)*

Introduction: The Upper Segment

Speaker Notes: Explain Step Pools and how they work

Introduction: This is a picture of the existing stream channel in the Middle Segment of Six Mile Creek

Speaker Notes:
- Repair/Improve Areas with Eroding Banks
- Improve Floodplain Connectivity
- No In-channel work

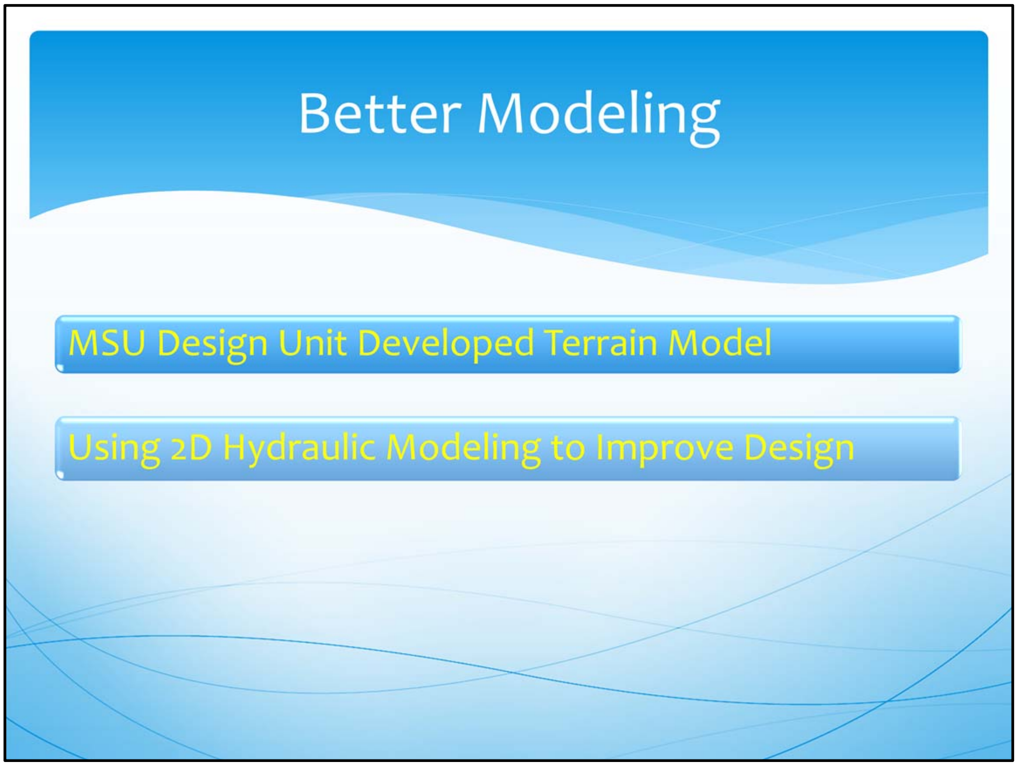
Introduction: The Lower Segment

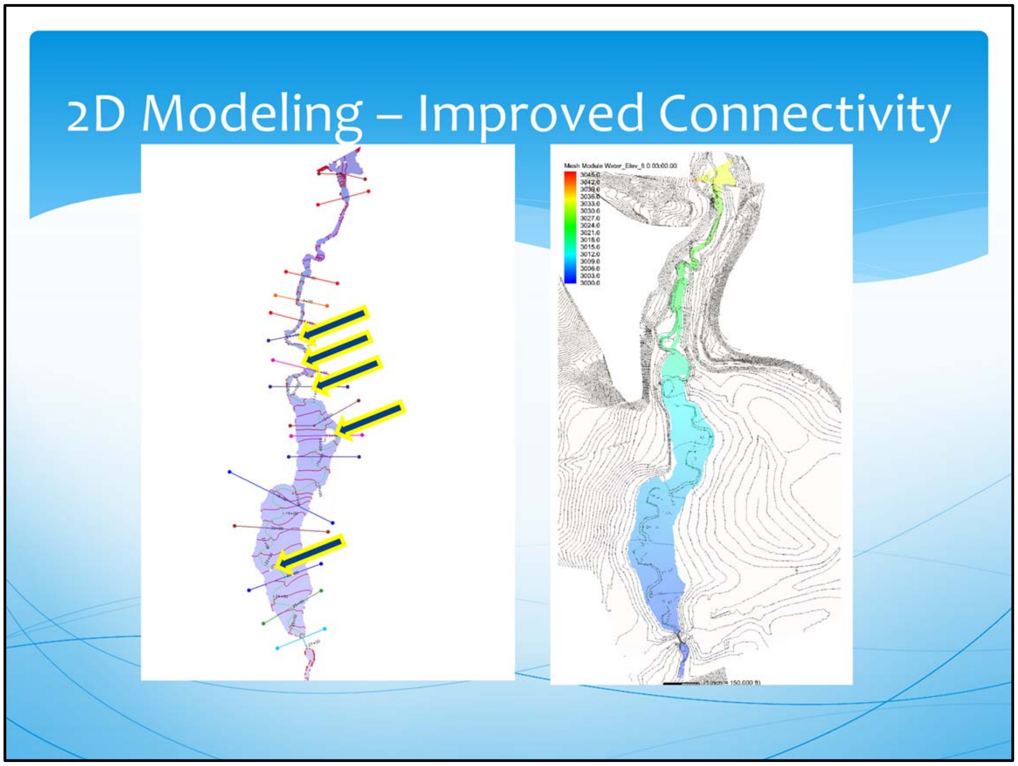
Speaker Notes:
The proposed alignment was developed to:
- tie into the existing channel at tangent segments both upstream and downstream,
- follow a historical path based on scars in aerial photographs and surveyed topography,
- avoid disturbing existing trees,
- fit the existing topography, and
- mimic the reference reach between the upper and lower channels in
    - channel geometry
    - sinuosity,
    - belt width.

Introduction: The Lower Segment

Speaker Notes:
The proposed alignment was developed to:

- tie into the existing channel at tangent segments both upstream and downstream,
- follow a historical path based on scars in aerial photographs and surveyed topography,
- avoid disturbing existing trees,
- fit the existing topography, and
- mimic the reference reach between the upper and lower channels in
  - channel geometry
  - sinuosity,
  - belt width.


Better Modeling
MSU Design Unit Developed Terrain Model
Using 2D Hydraulic Modeling to Improve Design

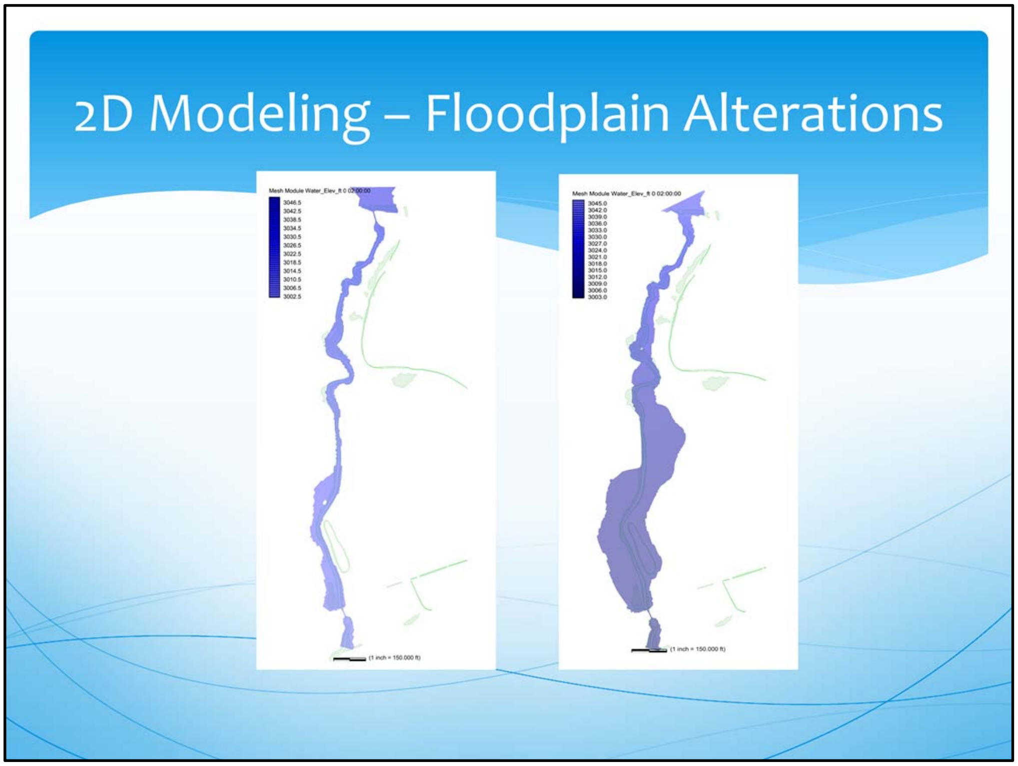


Introduction:

Speaker Notes:

Introduction:

Speaker Notes:



Introduction:

Speaker Notes:

Introduction:

Speaker Notes:

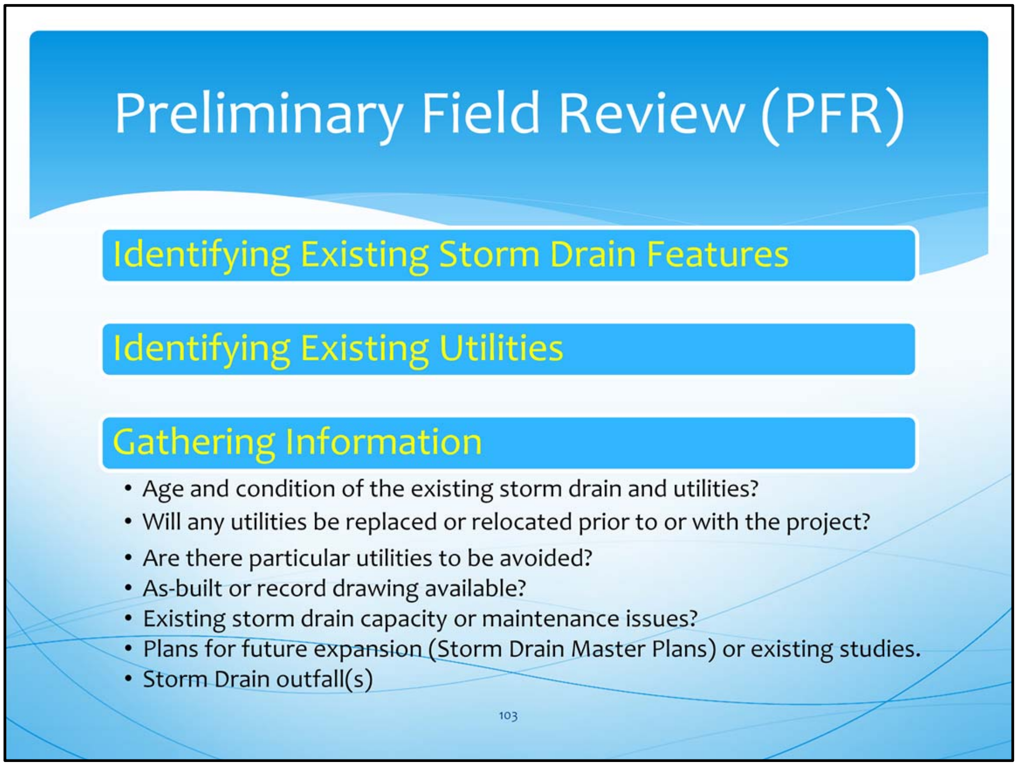
Introduction: Through the three projects we have greatly improved our stream restoration design knowledge and capabilities

Speaker Notes:
Through the three projects, we have seen our design processes evolve and improve.
Our plans have a greater level of detail and clarity, but still allow some wiggle room during construction.
Our Special Provisions have improved.
And our Construction Process has also improved.

Introduction:
Hello, my name is Kurt Marcoux and I am the Hydraulics Engineer for the Great Falls District.
Today I am going to talk about storm drain design utility coordination and the use of Subsurface Utility Engineering (S.U.E. for short) information.
The purpose of this presentation is to provide an overview of utility coordination required as part of the storm drain design process using the Cut Bank Urban project as an example.

Speaker Notes:
- The photos shown are not from the Cut Bank Urban project, but are some good examples of existing utilities in the vicinity of new storm drain construction.
- The photo on the left shows a new storm drain pipe being installed beneath an existing sanitary sewer line.
- The middle photos shows a new storm drain paralleling and existing utility line.
- The photo on the right shows a new storm drain that will cross an existing utility line.

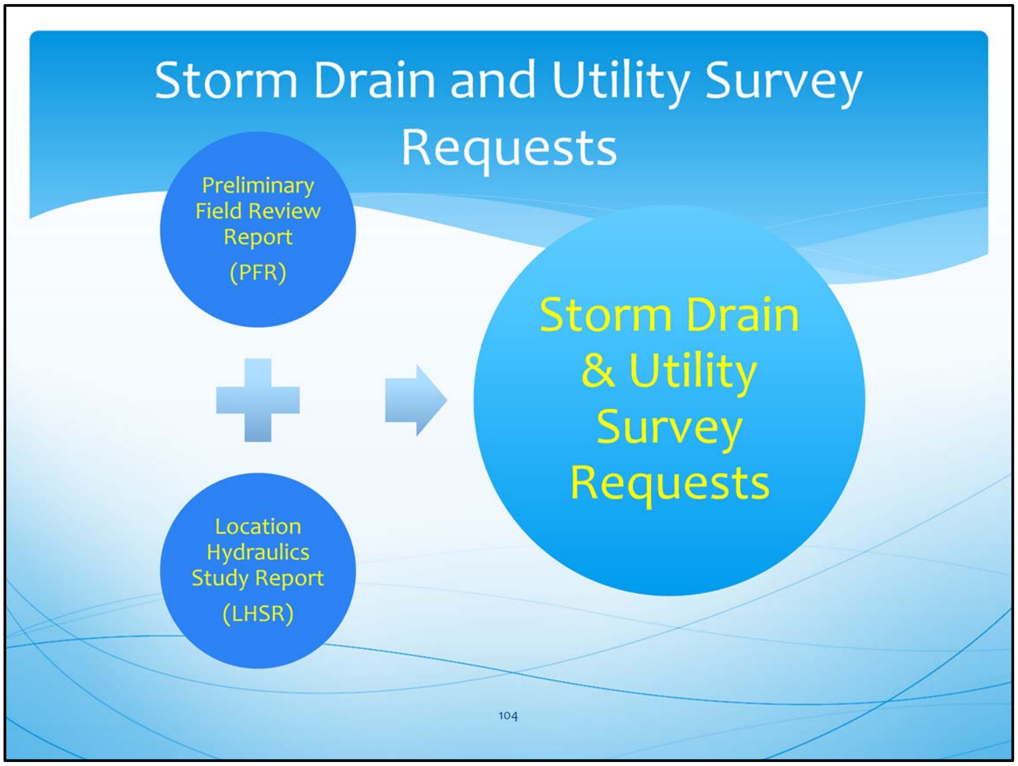
So where do we start? *(click)*



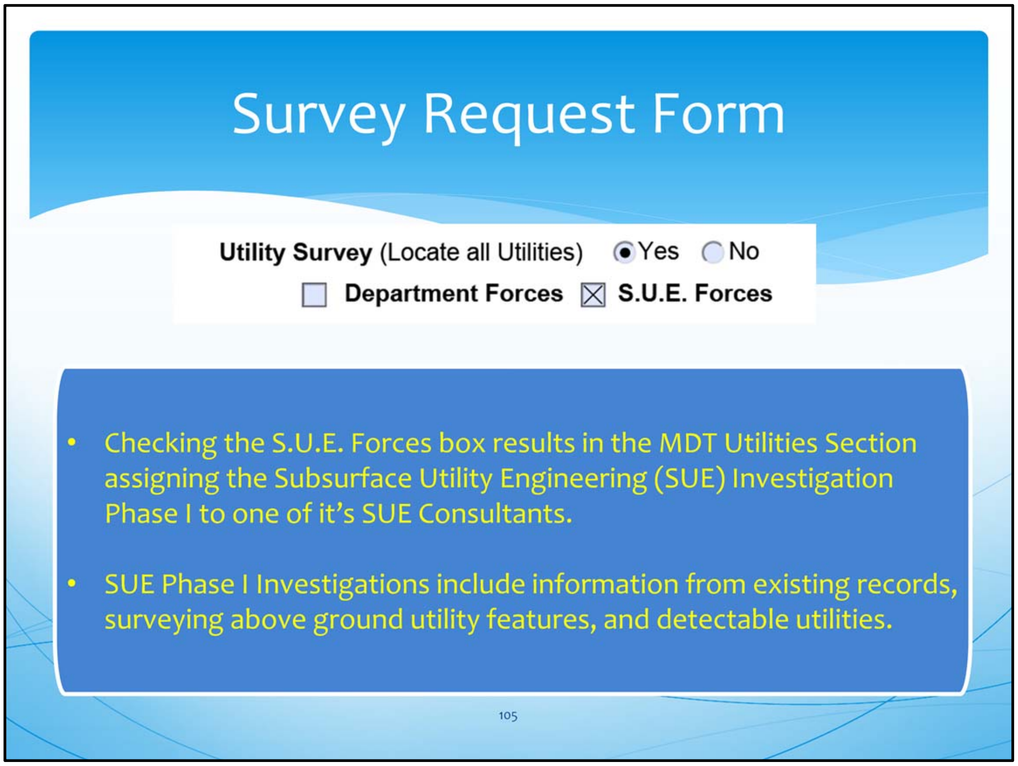
Introduction: It all starts during the Preliminary Field Review (PFR for short) with; *(click)*

Speaker Notes:

- Identifying Existing Storm Drain Features *(click)*;
    - Drop inlets, manholes, storm drain system outfalls, culverts, or sidewalk drains. *(click)*
- Identifying Existing Utilities *(click)*;
    - Power, water, sewer, gas, telephone, fiber optic, other *(click)*
- Gathering Information *(click)* ;
    - Age and condition of the existing storm drain and utilities?
    - Will any utilities be replaced or relocated prior to or with the project?
    - Are there particular utilities to be avoided?
    - As-built or record drawing available?
    - Existing storm drain capacity or maintenance issues?
    - Plans for future expansion (Storm Drain Master Plans) or existing studies.
    - Storm Drain outfall(s)



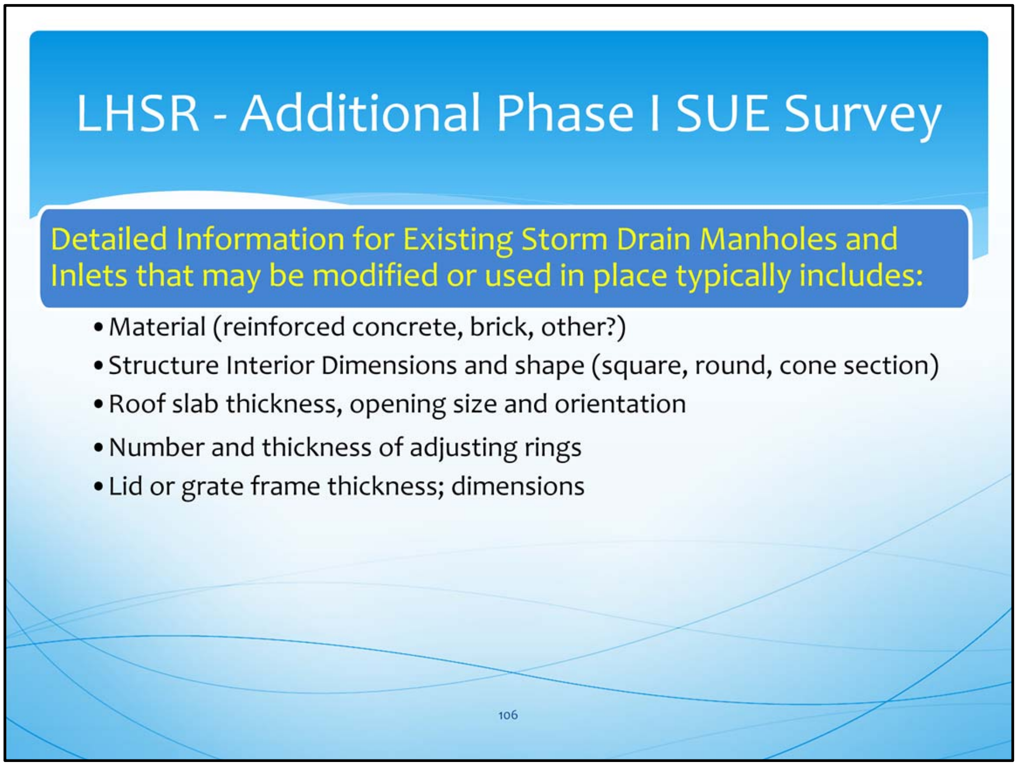
Introduction: After the PFR Review, the PFR Report is prepared by the Project Manager*(click)* and the LHSR is prepared by the Hydraulics Section *(click)* . *(click)* Both reports document preliminary information regarding existing utilities and storm drain and are used to develop the survey request for the project.



Introduction: The survey request form is completed by the Project Manager and includes a section for the Utility Survey. *(click)*

Speaker Notes:
(click) Checking the S.U.E. Forces box results in the MDT Utilities Section assigning the Subsurface Utility Engineering (SUE) Investigation Phase I to one of it's SUE Consultants. SUE Phase I investigations include information from existing records, surveying above ground utility features, and detectable utilities.

- **Locate utilities by S.U.E. Forces is typically selected for projects where utility conflicts are anticipated.**

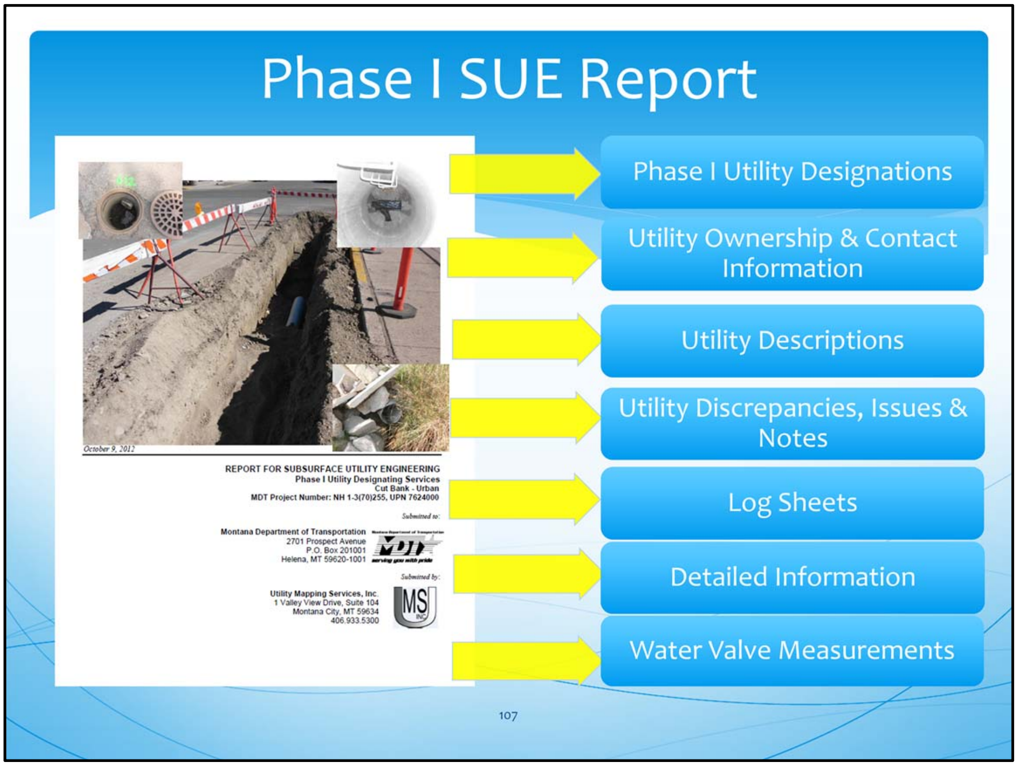


Introduction: The LHSR may request additional detailed information for existing storm drain manholes and inlets be included in the Phase I SUE Survey. *(click)*

Speaker Notes:

Detailed Information for Existing Storm Drain Manholes and Inlets that may be modified or used in place typically includes: *(click)*

- Material (reinforced concrete, brick, other?) *(click)*
- Structure Interior Dimensions and shape (square, round, cone section) *(click)*
- Roof slab thickness, opening size and orientation *(click)*
- Number and thickness of adjusting rings *(click)*
- Lid or grate frame thickness; dimensions *(click)*



Introduction: This is what a typical Phase I SUE Report may look like.

Speaker Notes:
Some of the standard information you will typically find in the SUE Phase I Report includes; *(click)*

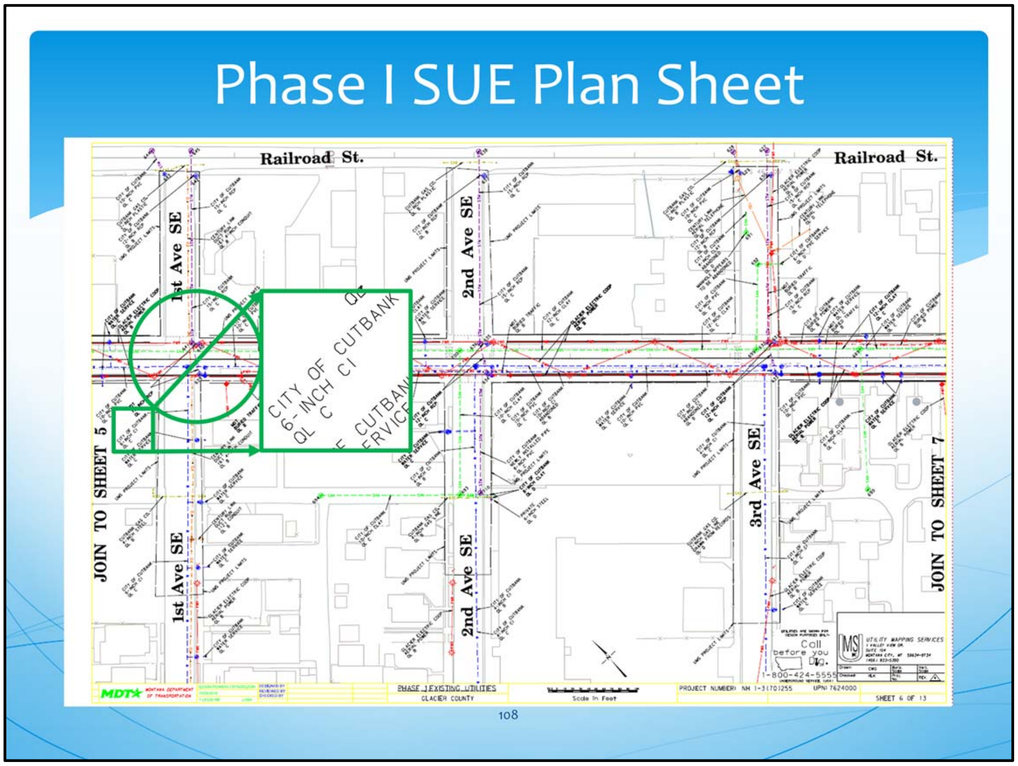
1. Phase I Utility Designations

➢ **The SUE Phase I Report documents mapped utilities and assigns them a Quality Level (A-D) based on the positional accuracy and data completeness per ASCE Standards. For example, utility information mapped only from historic records would be mapped at Quality Level D while surveyed utilities with x,y,z coordinates would be Quality Level A. A definition of the Quality Levels is included in the report. *(click)***

2. Utility Ownership and Contact Information *(click)*
3. Utility Descriptions
   - ➢ **Includes information regarding how the information was collected and Quality Levels of the utility mapping. *(click)***
4. Utility Discrepancies, Issues, and Notes *(click)*
   - ➢ **This section presents discrepancies between utility records and field findings, unusual utilities, and utilities found to have incomplete or conflicting information. *(click)***
5. Log Sheets
   - ➢ **Typically include storm drain inlets and manholes, sanitary sewer manholes, and culverts. *(click)***

6. Detailed Information
    - **As discussed in the previous slide, this information is typically requested in the LHSR for existing storm drain manholes or drop inlets.** ***(click)***
7. Water Valve Measurements
    - **These will be discussed further in a few moments (click)**

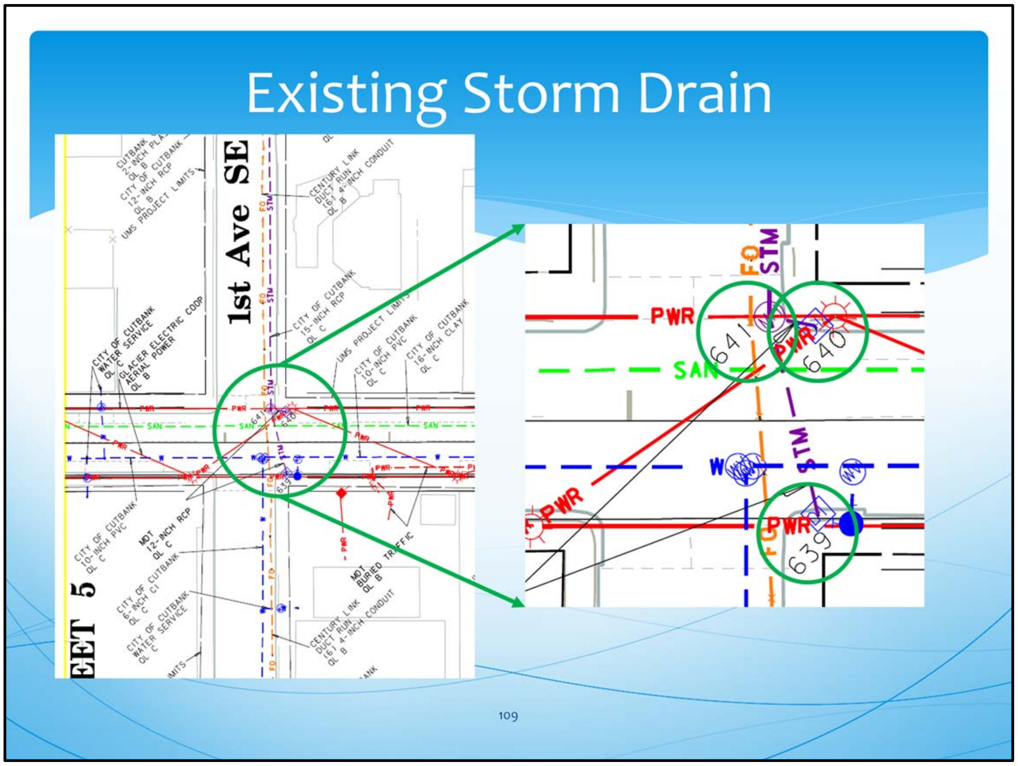
The Phase I SUE also includes a Utility Map File and Plan Sheets. (click)



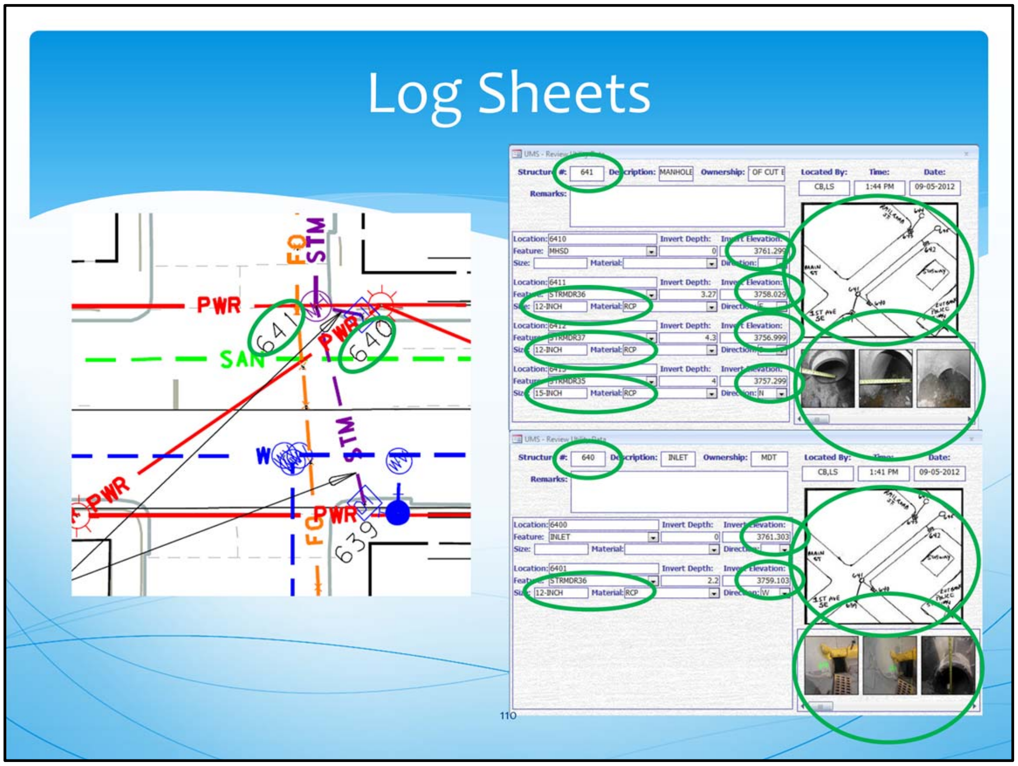
Introduction: This is an example of a Phase I utility plan sheet from the Cut Bank Urban project showing the mapped utilities. *(click)*

Speaker Notes:

- Here is a blowup of a callout for a water line. The callouts include the owner of utility, description or size and type of the utility, and quality level. This water line is owned by the City of Cut Bank and is a 6" cast iron mapped at Quality Level C . The Phase I Report notes that water mains that could no be consistently detected due to non conductive pipes or depth were designated Quality Level C. *(click)*
- We are going to look at the intersection of 1st Ave. SE and US2 in more detail with regard to the storm drain design and utilities. *(click)*



Introduction: Here is a blowup of the 1st Ave SE and US 2 intersection.
Speaker Notes:
- If we zoom in further on the existing storm drain shown in purple *(click)*
- We can see that the existing storm drain consists of two inlets, one in the SE quadrant *(click)* shown as Structure #639 *(click)* and one in the NE quadrant *(click)* shown as Structure #640 *(click)* , that connect to a manhole on the NE quadrant *(click)* shown as Structure #641.



Introduction: Log sheets are included with the SUE Phase I survey and typically include storm drain inlets and manholes, sanitary sewer manholes, and culverts.

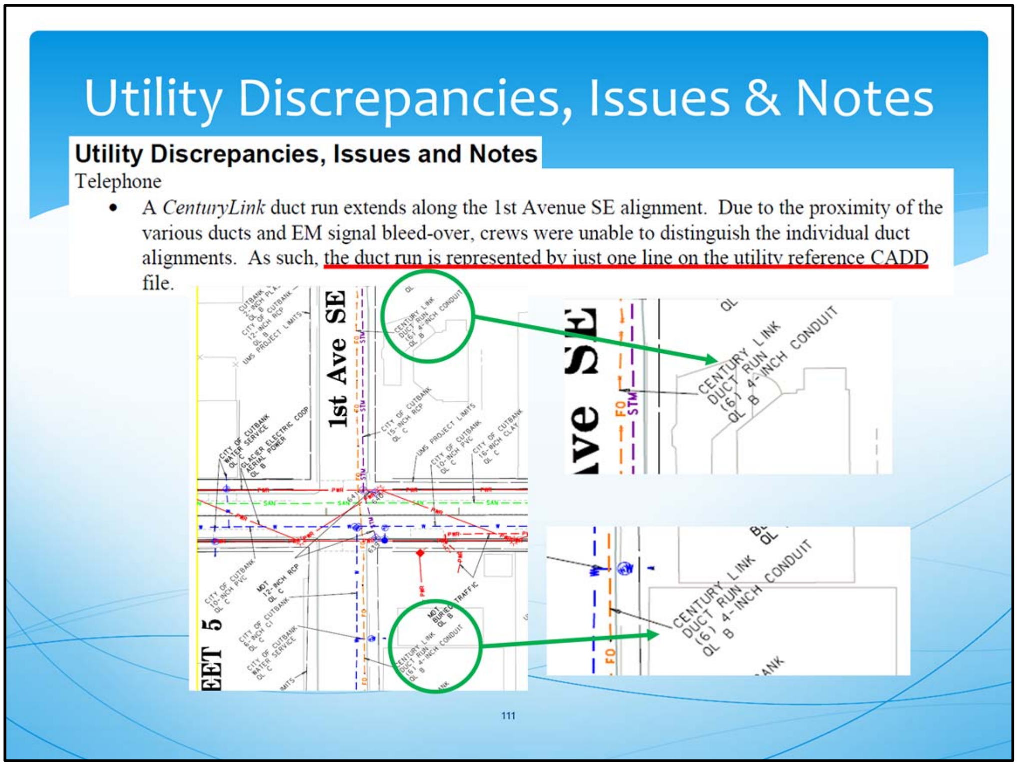
Lets take a look at a couple of the log sheets for the existing storm drain structures. *(click)*

Speaker Notes:

- *(click)* Here is the log sheet for structure #641 the existing storm drain manhole we discussed earlier. *(click)*
- *(click)* Here is the log sheet for structure #640 for the existing storm drain inlet in the NE quadrant. *(click)*

The SUE Phase I log sheets provide *(click)* :

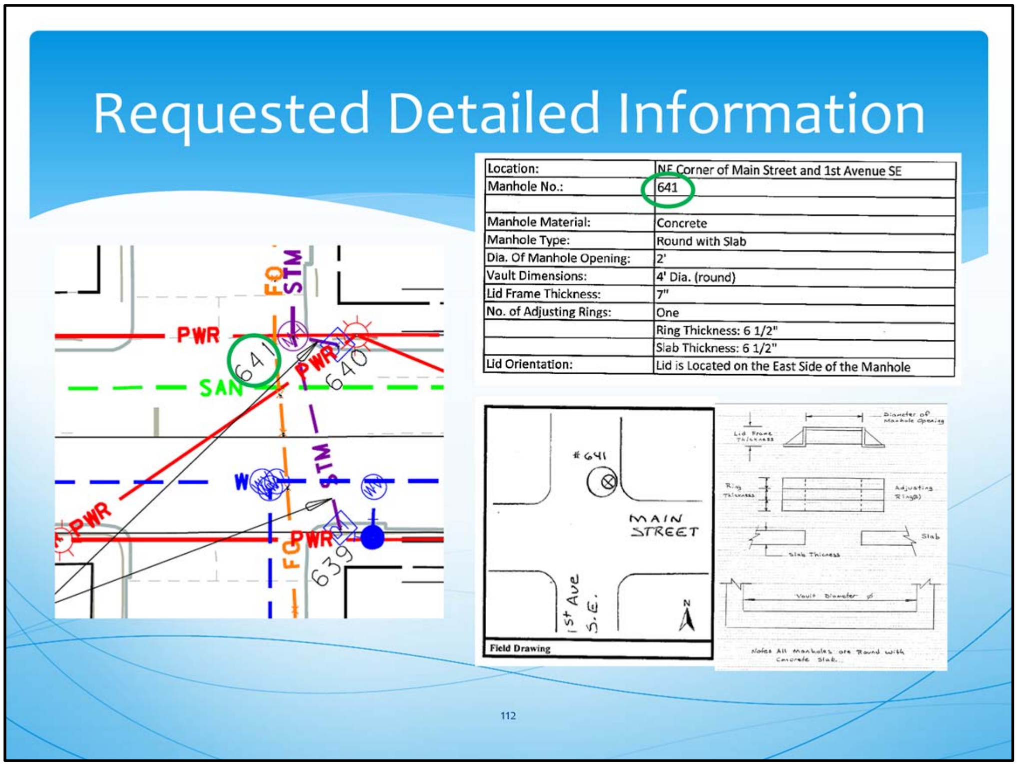
- The lid or grate elevation as well as the invert elevations of storm drain pipes entering or leaving the structure. *(click) (click)*
- The size and type of the storm drain pipes entering or leaving is also shown along with direction. *(click) (click)*
- A site sketch *(click) (click)*
- Photos of the structure are also included. *(click) (click)*



Introduction: The Phase I SUE Report includes a Utility Discrepancies, Issues, and Notes section that presents discrepancies between utility records and field findings, unusual utilities, and utilities found to have incomplete or conflicting information. This is an important section to review in conjunction with the Phase I mapping.

Speaker Notes:

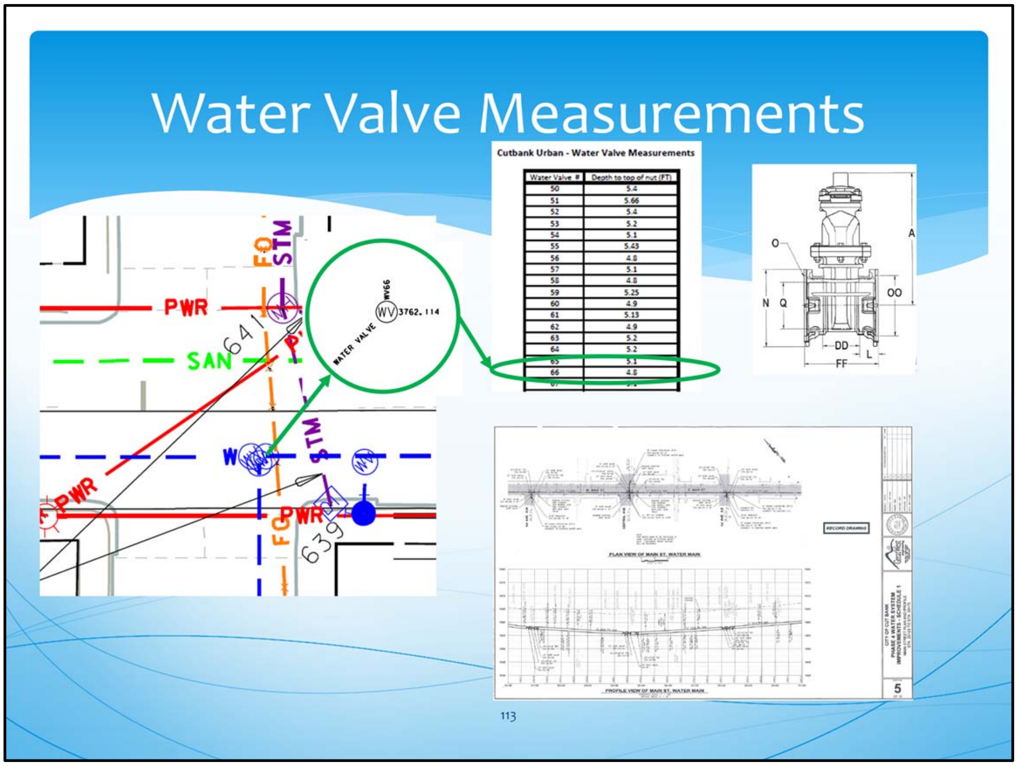
- On the Cut Bank Urban example *(click)*, *(click) (click) (click) (click)* the Phase I callouts show for the north/south Century Link telephone duct run consists of six four inch conduits. *(click)*
- The Utility Discrepancies, Issues, and Notes section for the Century Link duct run specifically notes *(click)* that the duct run is represented by just on line on the utility reference CADD file. The point here is that just looking at the utility map file it may not be apparent that a mapped utility has a width related to it. *(click)*



Introduction: The Location Hydraulic Study Report identified the existing manhole, Structure 641, *(click)* as a potential connection for the new storm drain and requested detailed information to determine if the structure could be modified and used in place or if it needed to be replaced with the project. *(click)*

Speaker Notes:

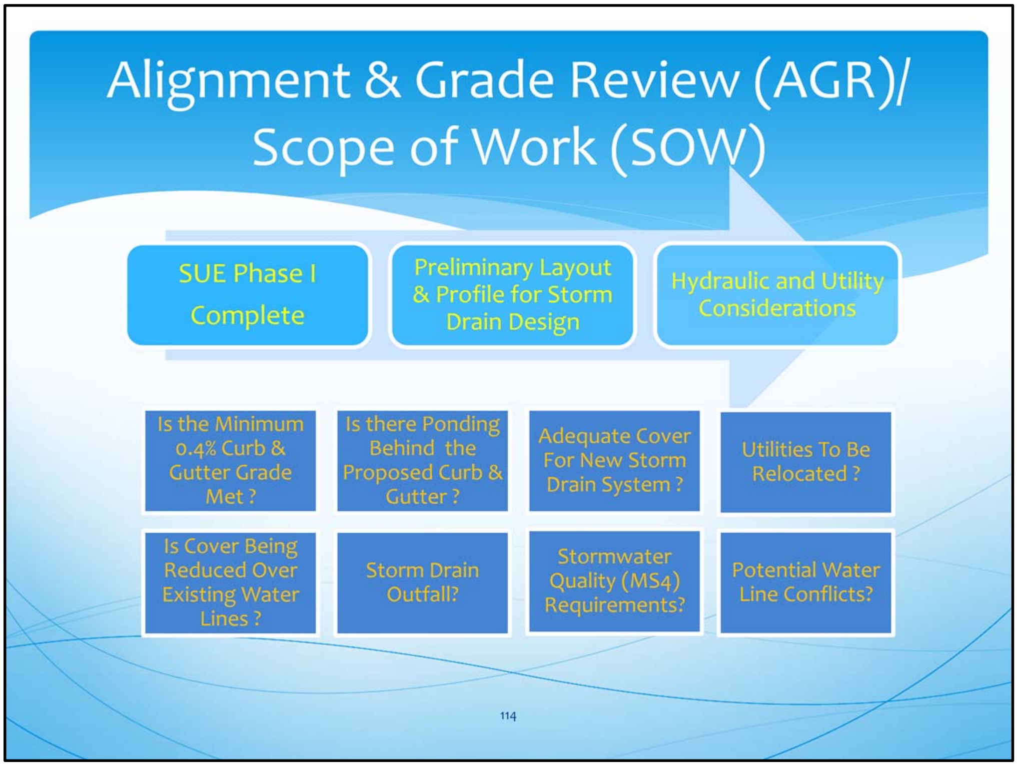
- The Detailed Information included all the information requested in the LHSR for the project such as material, manhole type, diameter of opening, vault dimensions, lid frame thickness, as well as the number and thickness of adjusting rings and slab thickness. *(click)*
- A field drawing showing the lid opening orientation was also provided *(click)*
- Along with a definitions sketch for the provided information. *(click) (click)*
- This information is important to determine if the manhole can be easily adjusted to accommodate lowering or raising of the profile and/or if it can be used in place and modified to accept new storm drain pipe. *(click)*



Introduction: As part of the Phase I SUE Survey, water valve lids are surveyed and a depth measurement taken from the top of the lid to the top of the valve. *(click)*

Speaker Notes:

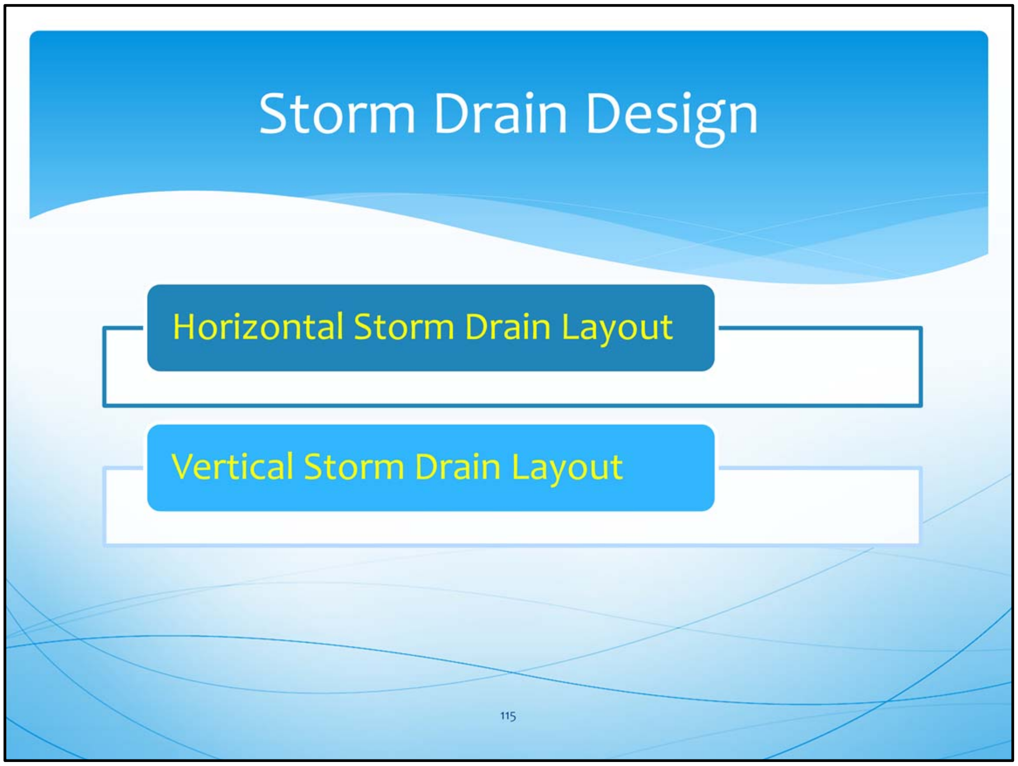
- Here is an example of the survey point for water valve 66 as well as the measure down information *(click)*. This provides an elevation to the top of the water valve. *(click)*
- The top of water line elevation can then be estimated from the water line valve dimensions and depth measurement. *(click)*
- If available, record drawings can also be used to approximate the elevation of water lines. *(click)*



Introduction: At the Alignment and Grade/Scope of Work stage of the design process the Phase I SUE will be complete *(click)*, we should typically have a Preliminary Layout & Profile for the Storm Drain Design *(click)*.

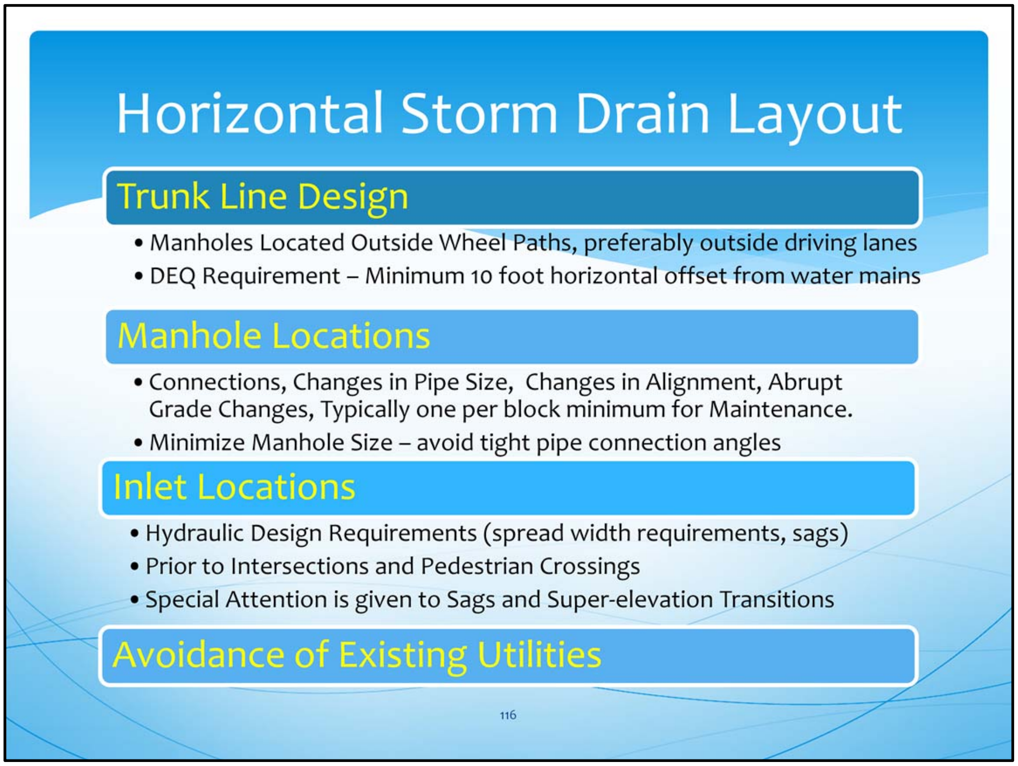
Speaker Notes:
Now we have some Hydraulic and Utility Considerations to look for such as*(click)*:

- Is the minimum 0.4% curb and gutter grade met? *(click)*
- Is there ponding behind the proposed curb and gutter?*(click)*
- Is there adequate cover for the new storm drain system? *(click)*
- Is it known if any of the utilities will be relocated? *(click)*
- Is cover being reduced over existing water lines? **Is it adequate for frost protection?** *(click)*
- Has the storm drain outfall been identified. *(click)*
- Are there any Stormwater Quality (MS4) requirements that need to be considered in the storm drain design? *(click)*
- Potential water line conflicts. *(click)*



Introduction: There are 2 main components to the storm drain design.

Speaker Notes:
- The horizontal storm drain layout
- The vertical storm drain layout



Introduction: Let me go through a brief overview the Horizontal aspects of a storm drain design for a typical urban project *(click)*

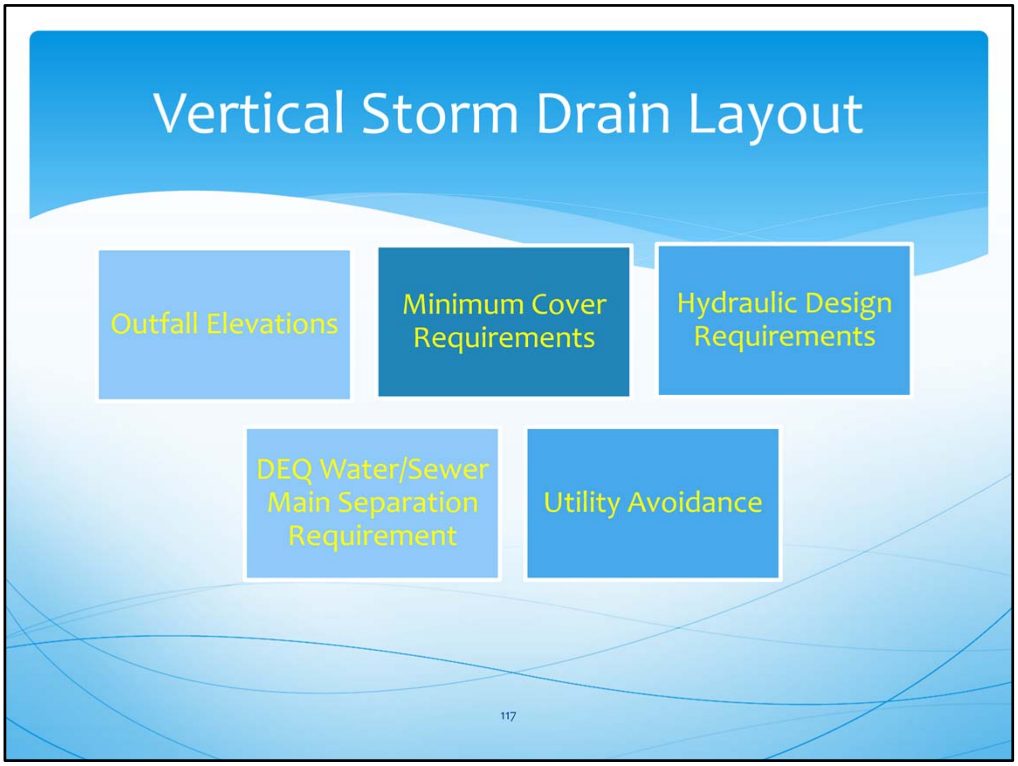
Speaker Notes:

- We have the Trunk Line design
  - The trunk line is laid out so that the manholes are placed outside of estimated wheel paths, and if at all possible outside the driving lanes altogether.
  - There is also a DEQ requirement of a 10 foot minimum distance between the new storm drain trunk line and any existing water mains. *(click)*

- Manhole Locations
  - Connections, Changes in Pipe Size, Changes in Alignment, Abrupt Grade Changes, Typically one per block minimum for Maintenance.
  - Minimize Manhole Size – Avoid tight pipe connection angles
    - **MDT criteria is a 12” minimum between outside edge of pipe walls connecting to manholes, so the more severe the connection angle the larger the manhole that will be required.** *(click)*

- Inlet Locations
  - Placed at all necessary Hydraulic Locations based on design spreadwidth and gutter profiles
  - Placed at all intersections and prior to pedestrian crossings
  - Special attention is given to sags and super-elevation transitions. *(click)*

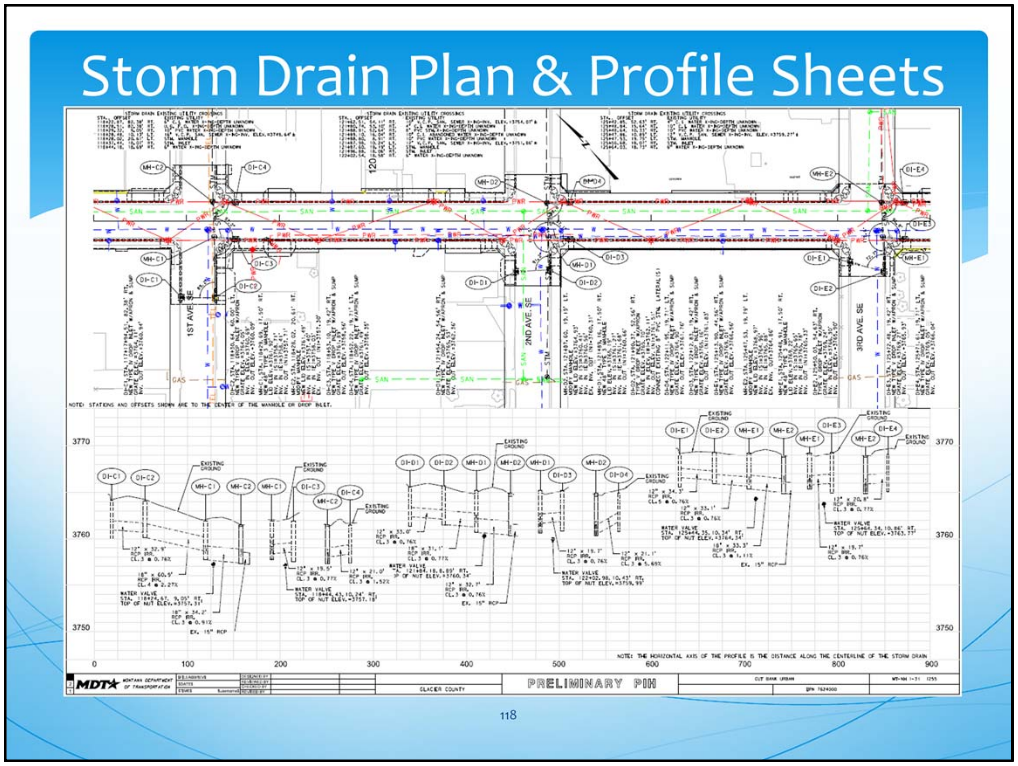
- Avoidance of Existing Utilities
    - **Trying to avoid as many existing utilities as possible while also identifying potential unavoidable impacts to be further investigated.** *(click)*



Introduction: Now let me give you a quick summary of the vertical aspects of a storm drain system. *(click)*

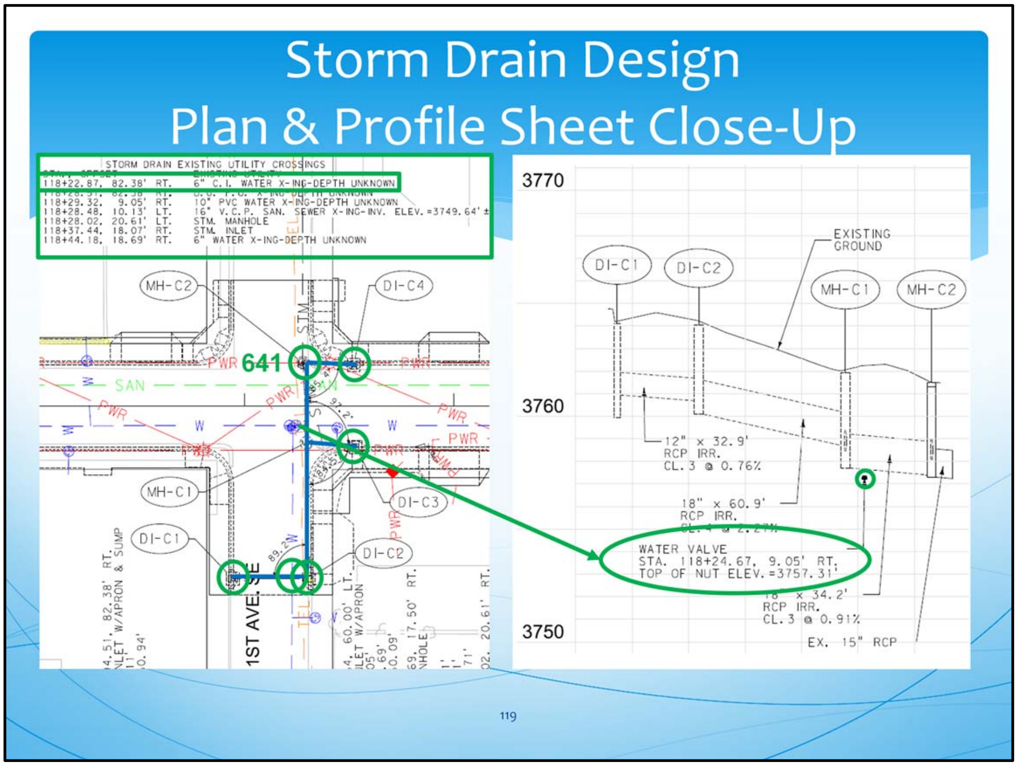
Speaker Notes:

- Outfall Elevations
    - **Match Outfall elevations at existing pipes and outfall channels.** *(click)*
- Minimum Cover Requirements
    - **A minimum 2 foot of cover is preferred.** *(click)*
- Hydraulic Design Requirements
    - **Assess the Hydraulic Design requirements such as; pipe sizes based on capacity, pipe slopes, velocities in trunk line sections, necessary drop met through access holes** *(click)*
- DEQ Water/Sewer Main Separation Requirement
    - **Verify the DEQ requirement of minimum 18 inch vertical separation between storm drain and water mains has been met.** *(click)*
- Utility Avoidance
    - **Trying to avoid existing utilities while also identifying potential impacts to be further investigated.** *(click)*



Introduction: Once the Hydraulic Design of the new storm drain system has been completed, the storm drain plan and profile sheets are created.

Speaker Notes: Here is an example of a storm drain plan and profile sheet for the Cut Bank Urban project at the PIH stage.



Introduction: Lets look closer at the intersection of 1st Ave SE and US 2 on Cut Bank Urban as an example of the type of utility conflict information that is shown on the storm drain plan and profile sheets.

Speaker Notes:

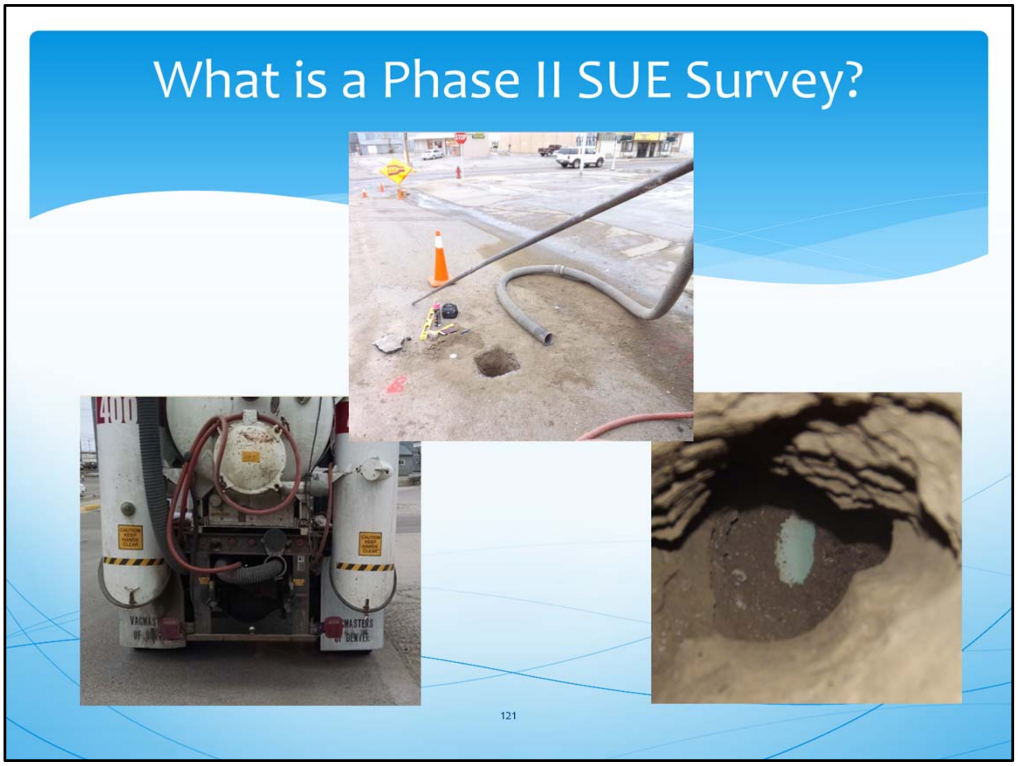
- Here is our new storm drain layout *(click)*
  - New inlets were designed on the south leg and east leg of the intersection*(click)* and connected into the existing manhole MH-C2 *(click) (click)*
  - Storm Drain Utility Crossings *(click)* Here you can see the utility crossing information at the top of the page showing the location of known existing utilities crossing the storm drain. You can see a station, offset, a description of the utility and a elevation if the Phase I SUE provided that information. For example *(click)* here is a water line crossing the proposed storm drain.
    - If the depth is not known you will see “Depth Unknown” as shown for this water line crossing. (click)

- Next lets look at the storm drain design in profile view (click)
  - Proposed storm drain pipe size, type, slope and length are shown in the profile view.
  - Know or approximated utility crossings are also shown. *(click)* Here you can see a water valve adjacent to the new storm drain trunk line with station, offset and an elevation from the Phase I water valve measure down information. *(click)*

Introduction: Now let's go through some things to review during Plan in Hand to insure the success of the storm drain interaction with the existing utilities

Speaker Notes:

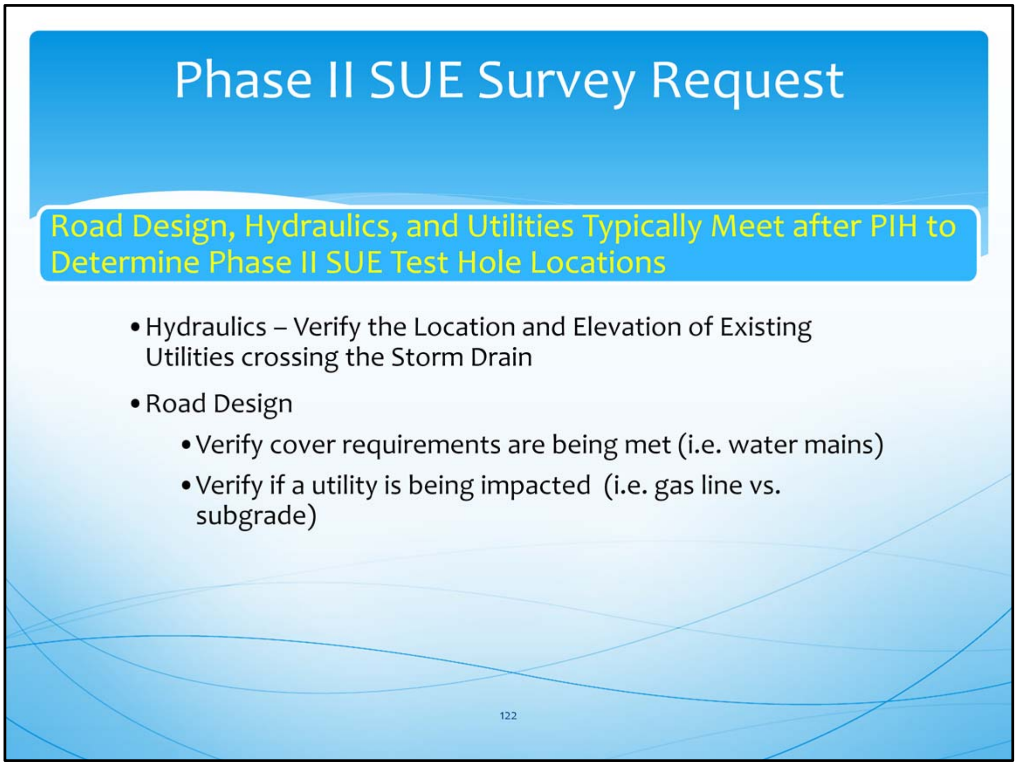
- Discuss Which Utilities Will Be Avoided and Which Will Be Relocated
  - **Don't need to avoid if being relocated.**
- Check for Storm Drain Conflicts with Road Design Features
  - **Are there any inlets located in approaches?**
  - **Are there any conflicts at pedestrian ramps?**
  - **Do inlets align with curbs?**
- Check for Storm Drain Conflicts with Existing Utilities
  - **Depth Unknowns – Do we need more information for certain crossings?**
- Discuss Phase II SUE Needs – Follow up meeting after PIH
- DEQ Horizontal and Vertical Separation Requirements
  - **May need SUE more information to determine if vertical separation is being met.**
- Water Valves and Hydrants – Adjustment or Relocations Needed?



Introduction: What is a Phase II SUE Survey? (click)

Speaker Notes:
A Phase II SUE Survey consists of vacuum excavated test holes used to expose an existing utility. The exposed existing utility can then be surveyed and tied vertically and horizontally to the project survey control.

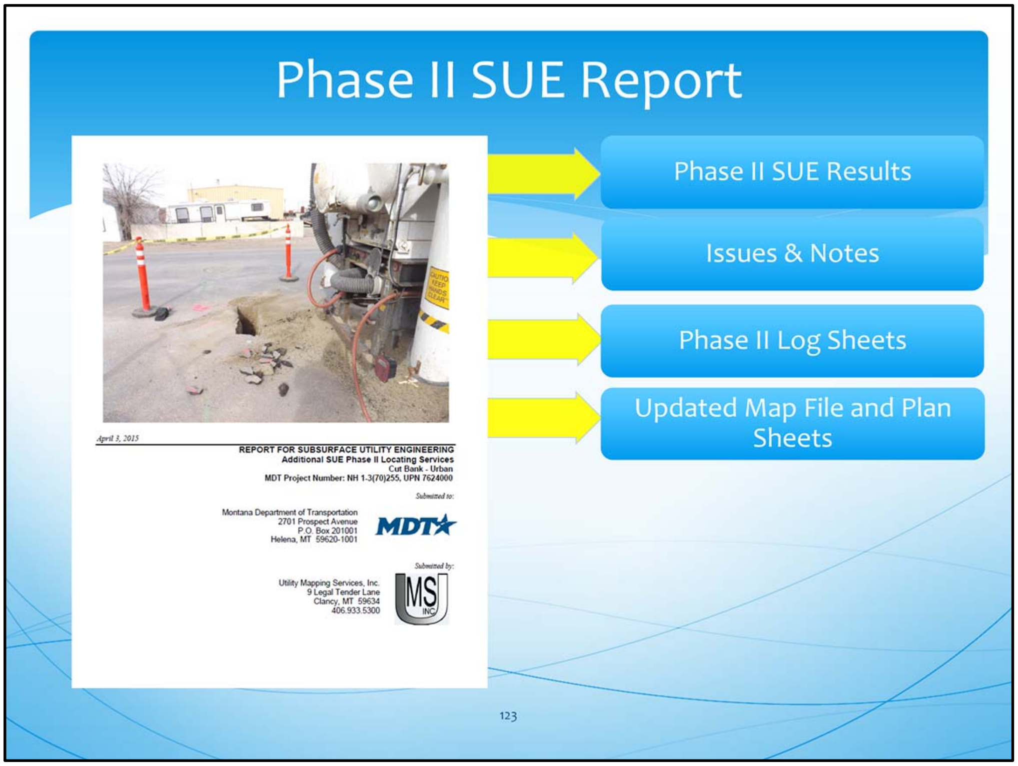
- **Vacuum excavation avoids damaging the existing utility.** (click)



Introduction: Phase II SUE Survey Request *(click)*

Speaker Notes:

- A meeting with Road Design, Hydraulics, and Utilities to Determine Phase II SUE Test Hole Locations is typically scheduled after PIH. *(click)*
- Hydraulics – Verify the Location and Elevation of Existing Utilities crossing the Storm Drain. Can the design be revised to avoid them. *(click)*
- Road Design *(click)*
    - Verify cover requirements are being met (i.e. water mains).
        - **Frost protection.** *(click)*
    - Verify if a utility is being impacted (i.e. gas line vs. subgrade) *(click)*

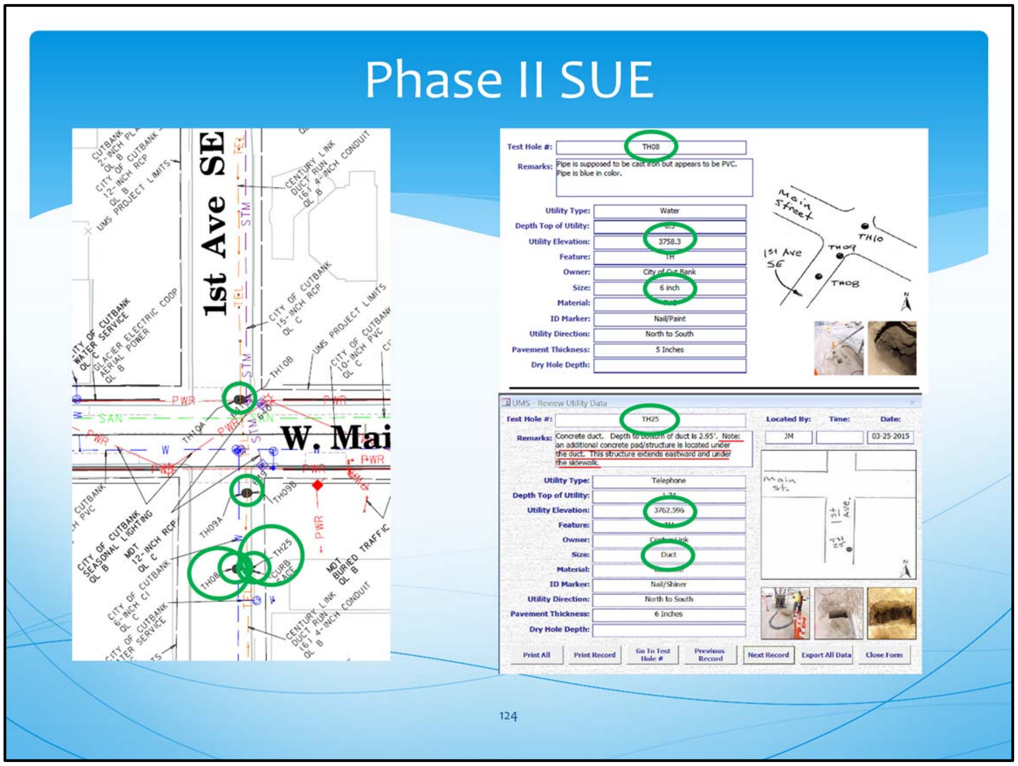


Introduction: Here is an example of a Phase II SUE Report from the Cut Bank Urban project.

Speaker Notes:

The Phase II SUE Report typically includes:*(click)*

- Phase II SUE Results *(click)*
- An Issues and Notes Section noting special conditions and field findings. *(click)*
- Phase II Log Sheets *(click)*
- Updated Map File and Plan Sheets *(click)*

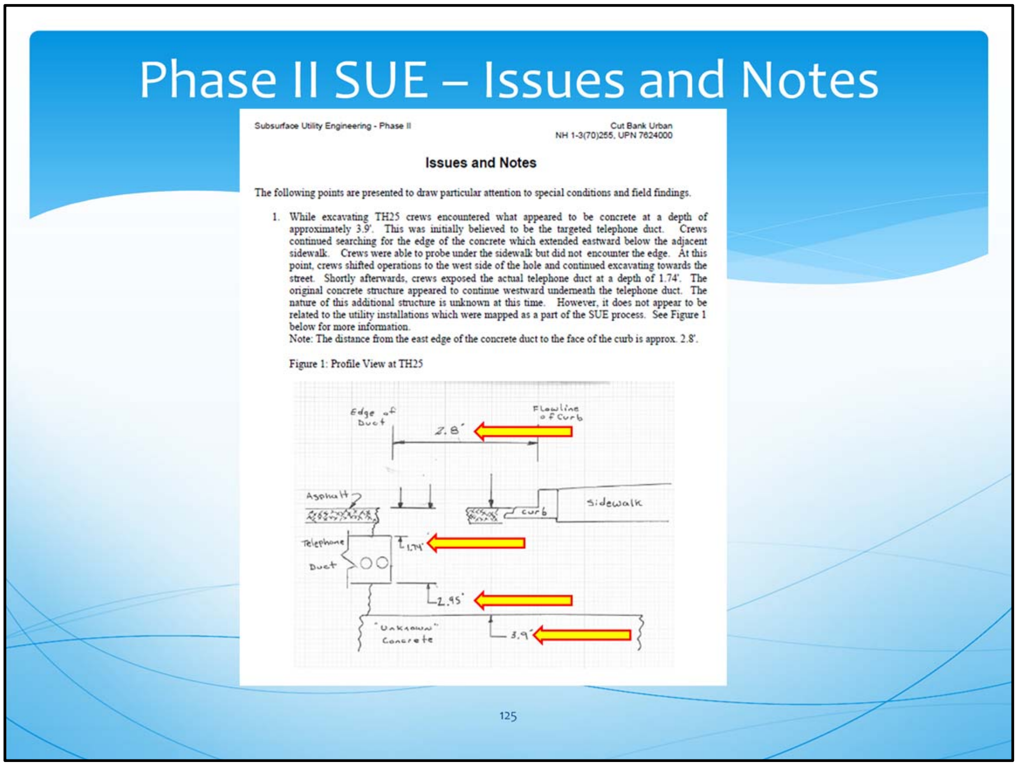


Introduction: Lets go through the Phase II SUE investigation for the 1st Ave SE and US-2 intersection that we have seen on previous slides. *(click)*

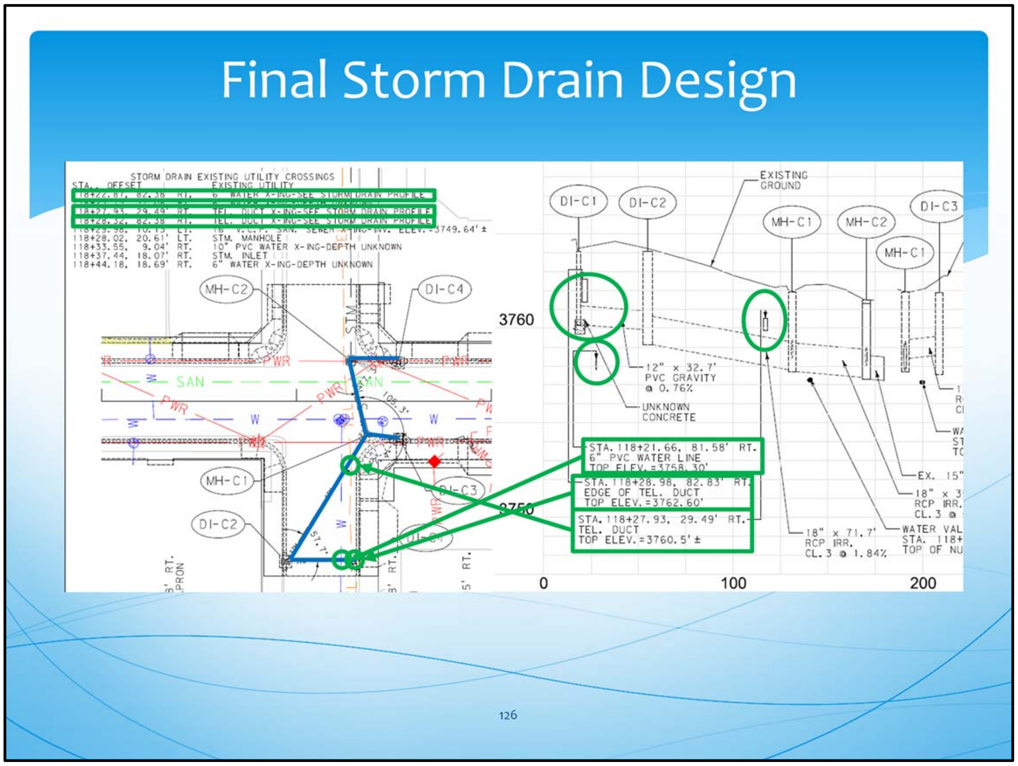
Speaker Notes:

- The first round of Phase II Test Holes included TH08 to locate a water line and TH9 and TH10 to located a telephone duct system. *(click)* TH 25 was taken at a later date to verify the proposed inlet would not be in conflict with the telephone duct. *(click) (click)*

- Here is the Phase II log sheet for TH08. *(click) (click)*
    - The utility elevation and size are shown on the log sheet with the surveyed location included in the map file. *(click)*
- Here is the Phase II log sheet for Test Hole 25. *(click)*
    - Again the elevation of the top of the utility is shown. Note that under size it simply states “Duct”. *(click)*
    - The remarks note that an additional concrete/pad structure is located under the duct. Let’s take a look a the Issues and Notes Section of the Phase II Report for further information.



Speaker Notes:
This is the issues and notes section for TH25 included with the Phase II SUE for the Cut Bank Urban project. This information is in addition to the information provided in the log sheet. The sketch provides dimensional information *(click) (click)* relating the telephone duct to the curb, and unknown concrete. Now we know the location and elevation of these features. *(click)*



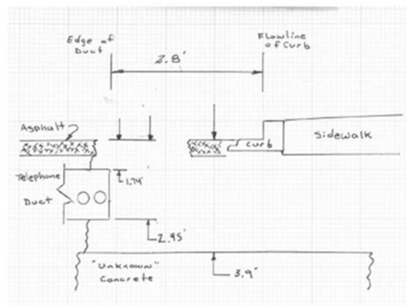
Introduction: Here is the Final Storm Drain Design for the intersection designed to avoid the Century Link duct. *(click)*

Speaker Notes:

- The storm drain alignment was revised to cross the telephone duct instead of paralleling it as it was at PIH. *(click)*
- The storm drain profile was adjusted based on the SUE II information to avoid impacting the telephone duct at two locations. *(click) (click)*
- The SUE II dig information for the water line was added as well. *(click)*

Special Provision

33. <u>DI-C1, STA. 118+30.93, 82.38' RIGHT – DROP INLET AND LATERAL INSTALLATION</u>
The subsurface utility investigation for the project located what appeared to be buried concrete between the edge of the existing telephone duct at station 118+28.98, 82.83' Right and existing curb as shown in the following diagram:



The lateral extents and thickness of this unknown buried concrete is undetermined. The unknown concrete is in conflict with the drop inlet DI-C1 at station 118+30.93, 82.38' Right as well as the lateral storm drain pipe. Remove the unknown concrete as needed to facilitate installation of the drop inlet and storm drain lateral pipe. Include materials, labor and equipment needed to remove the unknown concrete in the unit price bid for the drop inlet. No additional payment will be made.

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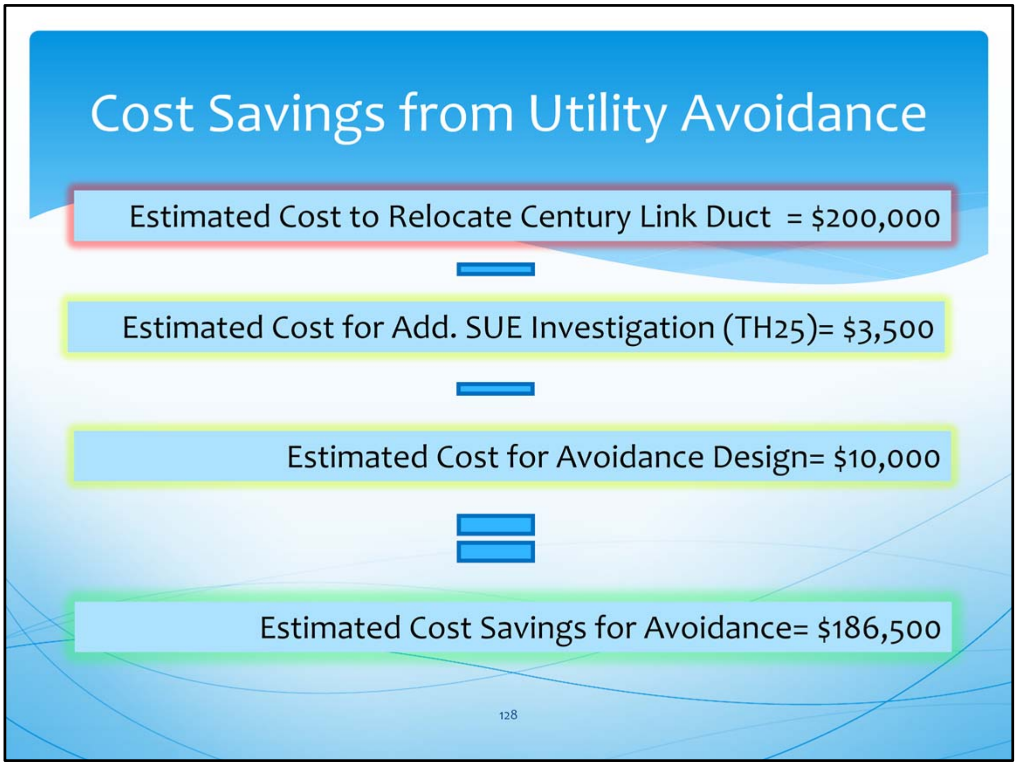
Speaker Notes:
The sketch for Test Hole 25 from the SUE Phase II Issues and Notes section was used in a special provision to make the contractor aware of the unknown concrete is in conflict with the proposed drop inlet and it will need to be removed to facilitate the installation of the inlet and lateral pipe.



Introduction: This is an example of the cost savings that can be seen if utilities can be avoided ahead of time during the design process.

Speaker Notes:

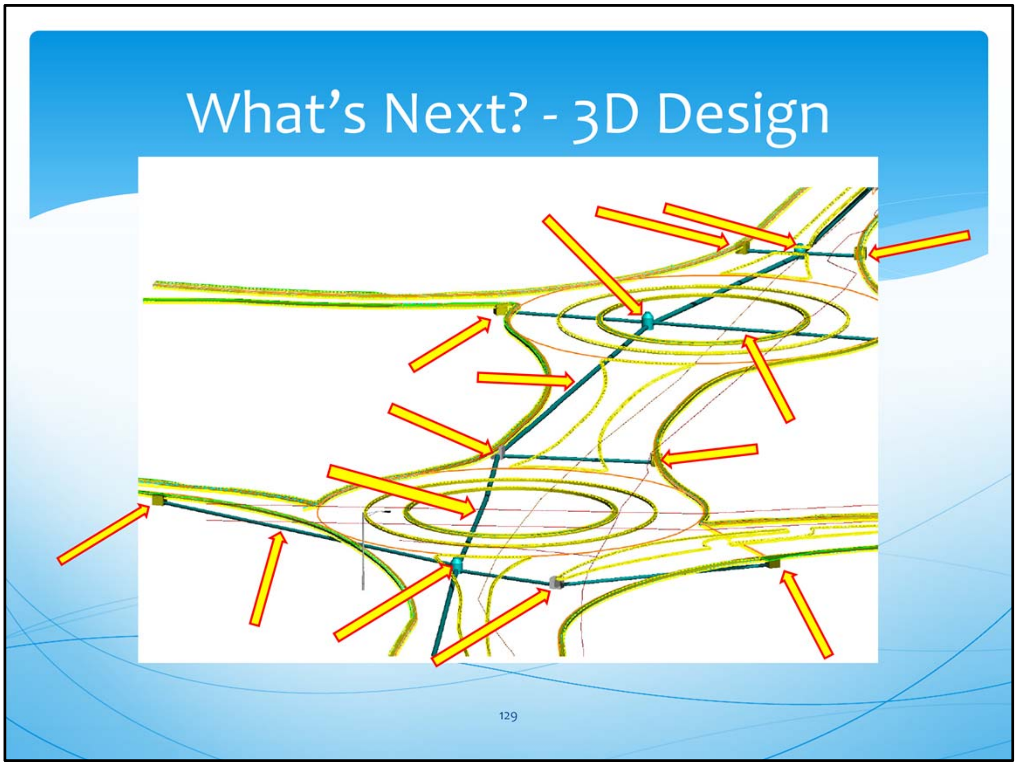
Estimated Cost to Relocate Century Link Duct = $200,000 *(click)*

- **MDT cost is 75% of total. Requires relocating approximately 500 feet of duct between existing utility vaults.**
- **This is just one example of avoidance on the project.**

Estimated Cost for Add. SUE Investigation (TH25)= $3,500 *(click)*

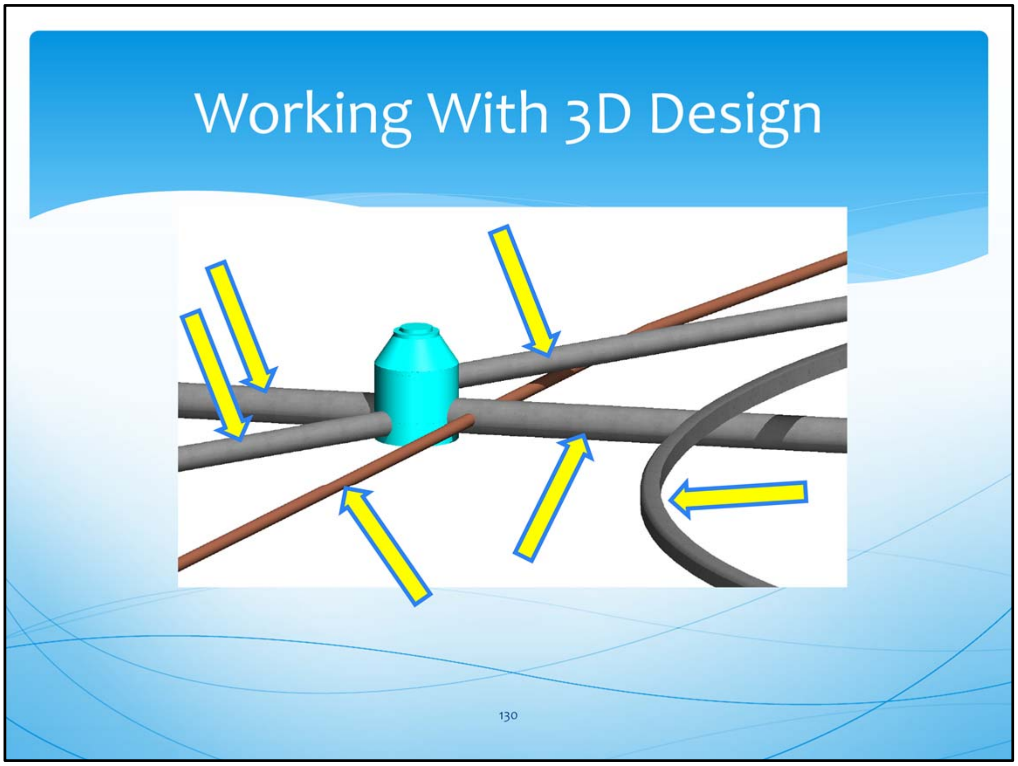
Estimated Cost for Avoidance Design= $10,000 *(click)*

Estimated Cost Savings for Avoidance= $186,500 *(click)*



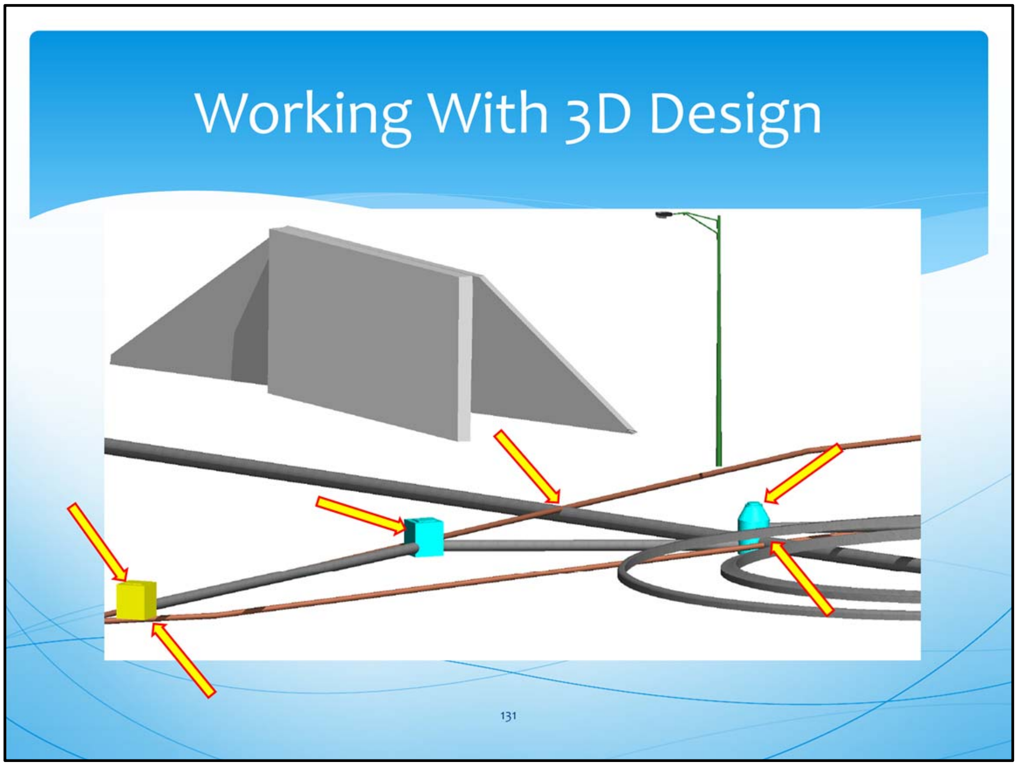
Introduction: As everyone knows, we are working towards using 3D design for developing our project plans. Let me briefly show you some of the really cool improvements we will see with regards storm drain layout and utility impacts.

Speaker Notes: Here you can see the design for VanBuren Street in Missoula; the different access holes, the various inlets, and the pipes in between.



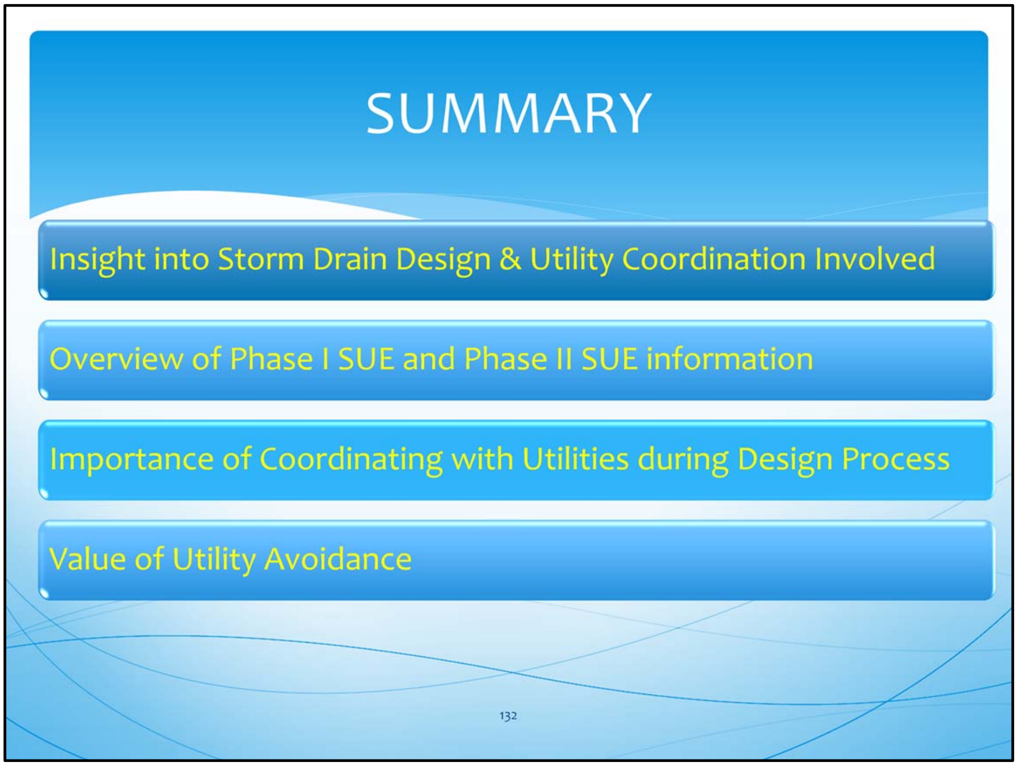
Introduction: Here is close up of a specific access hole showing; the trunk line *(click to show arrow, click to remove)*, inlet laterals *(click to show arrows, click to remove), new concrete curb (click to show arrow, click to remove), and a conflicting utility (click to show arrow, click to remove)*.

Speaker Notes:



Introduction: Here is another 3D design view. You can see the manhole *(click to show arrow, click to remove)*, two drop inlets *(click to show arrows, click to remove)*, but most importantly you can see the multiple utility impacts *(click to show arrows, click to remove)*.

Speaker Notes:

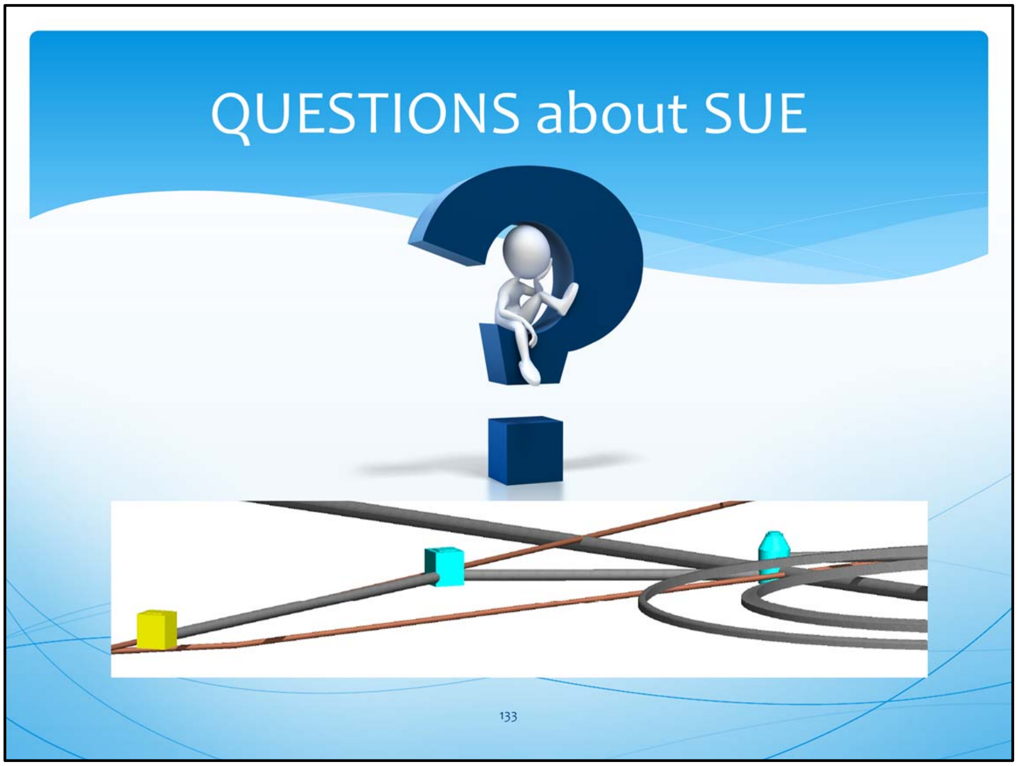


Introduction: Now lets go through a quick Summary

Speaker Notes:

My hope is that this presentation provided you the following: *(click)*

- Insight into Storm Drain Design and the Utility Coordination Involved
    - **Including the process involved to identify and avoid utilities as well as the additional SUE information and design revisions that may be necessary for avoidance.** *(click)*
- Overview of Phase I SUE and Phase II SUE information
    - **Made you aware of Quality Levels, report information, issue and notes, logs sheets, and water valve measurement.** *(click)*
- Importance of Coordinating with Utilities during Design Process
    - **Early and continuous coordination with MDT Utilities expedites the design process.** *(click)*
- Value of Utility Avoidance*(click)*



➢ Thank you for attending. Are there any questions?

Questions about What's New

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